A report of the
CANEUS Fly-by-Wireless 2009 Workshop
June 8-12th, 2009, Montreal, Canada

FLY-BY-WIRELESS FOR AEROSPACE VEHICLES

About

COVER AND BOOK DESIGN

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ABOUT CANEUS AND THE FBW CONSORTIUM

CANEUS International is a non-profit organization that seeks to benefit the aerospace industry by fostering international public/private partnerships between industries, research laboratories, and government stakeholders. CANEUS aims to mitigate the high cost and risk of advanced technology development by defining and executing these projects and initiatives through collaborative partnerships.

The CANEUS Fly-by-Wireless (FBW) Consortium is the steward of the aerospace industry's strategic and technology roadmap for wireless technologies. The CANEUS "Fly-by-Wireless" Consortium has established a collaborative environment wherein resources from member organizations are pooled to focus on high-risk, high-cost initiatives aimed at accelerating the infusion of emerging wireless technologies into aerospace applications and promote intra-project coordination.

For more information on CANEUS, visit: *http://www.caneus.org*

For more information on the Fly-by-Wireless Workshop committee, visit: *http://www.caneus.org/fbw/*

ABOUT THIS DOCUMENT

This document is the result of the Fly-by-Wireless Workshop held in June 2009 in Montreal hosted by the CANEUS International organization in partnership with the École Polytechnique de Montréal, the National Research Council of Canada, Industry Canada, and Bombardier. This report will serve as a guide for the project participants and the organisations interested in funding and participating in said projects. In the long term, it will serve as a reference guide for individuals interested and involved in developing fly-by-wireless concepts for aerospace systems.

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FLY-BY-WIRELESS FOR AEROSPACE VEHICLES

Acknowledgements

The authors of this report wish to extend their gratitude and thanks to the following individuals who helped contribute to the 2009 Fly-by-Wireless Workshop and make this document a reality. First, to the hosts and partners of the workshop itself: Industry Canada, National Research Council Canada, Pratt & Whitney Canada, Bombardier Aéronautique, Canadian Space Agency, RESMIQ, IEEE Aerospace and Electronics Systems Society, and the École Polytechnique de Montreal.

Many thanks to the workshop committee members:

- Roy Vestrum, NRC-IAR-FRL
  Organizing Committee Chair
- David Russel, National Research Council Canada
  Technical Co-Chair
- Jim Castellano, Industry Canada
  Technical Co-Chair
- Jules O'Shea, École Polytechnique de Montreal
  Hosting Chair
- André Bazergui, CRIAQ
- Somen Chowdhury, Bell Helicopter Textron
- Rick Earles, CANEUS International
- Jacques Lyrette, Innovative Matériels
- Fidele Moutpfouma, Bombardier Aerospace
- Nezih Mrad, Department of National Defense
- Claude Perron, AMTC, NRCC
- Allan Reyes, CANEUS International
- Peter Lance, Pratt & Whitney
- Wanping Zheng, Canadian Space Agency

Credit is also extended to the conference support staff who helped organize the workshop and oversee all the planning, especially Prof. Jules O'Shea who helped coordinate all the logistics with our co-host École Polytechnique.

Special appreciation is also due to all the speakers whose presentations and notable input served as a foundation for this report as well as the facilitator support from the Dawnbreaker group who helped synthesize all the ideas put forth during the workshop activities and enabled the formation of project concepts.

Finally, thanks to the project team leaders who assisted and synthesized the final projects that emerged from the workshop breakout sessions: David Russel National Research Council, William (Cy) Wilson NASA Langley Research Center, Douglas Goodman Ridgetop Group Inc., and Mourad El-Gamal McGill University.

Preface

This report is the result of the Fly-by-Wireless (FBW) 2009 workshop for aerospace vehicles held in June 2009 at the École Polytechnique in Montreal, Canada by the CANEUS International Organization; in an effort to stimulate the formation of collaborative projects and to promote the advancement of a broad range of wireless technologies for use by the global aerospace industry. The CANEUS "Fly-by-Wireless" Consortium has established a collaborative environment wherein resources from member organizations are pooled to focus on high-risk, high-cost initiatives aimed at accelerating the infusion of emerging wireless technologies into aerospace applications.

The FBW Consortium vision is to minimize cables and connectors across the aerospace industry by providing reliable, lower cost, higher performance alternatives for a vehicle/program's life cycle. The FBW Consortium is chartered with creating and sustaining the entire "ecosystem" for wireless technologies for aerospace applications. Moreover, the Fly-by-Wireless Consortium is chartered with providing a platform for cooperation and partnerships between industry/government customers, system integrators, and technology developers, while exchanging public and published information on the state-of-the-art wireless alternatives and new innovations. In summary, the CANEUS "Fly-by-Wireless" Consortium, with a strong participation by worldwide end-users, has established a robust supply chain to sustain the entire technology development pipeline. The Consortium also acts as the broker for licensing intellectual property jointly developed by its collaborative consortia.

The FBW09 workshop began with presentations, panel sessions and then round-table discussions which led to the identification of the potential project concepts. The workshop then culminated in several breakout group sessions on the final day. These breakout sessions provided an opportunity for workshop participants to assist in project development and refinement.

This report on the FBW09 Workshop first lays out an executive summary of the report and includes information on the FBW Consortium, its mission, vision and goals, a summary of the sessions and the workshop outcome. This chapter is followed by a general introduction that provides a backdrop for Fly-by-Wireless technology and its strategic importance in aerospace vehicles and vehicle safety. The next five chapters provide readers with overviews of the central topics that were under discussion: namely a FBW Consortium overview, framework and issues, aeronautics, space, and defense needs, current technological developments, funding and success criteria.

Chapter six forms the core of this report- it illustrates in detail the four project concept proposals that emerged from the workshop. Following this are the findings from the workshop based on these proposals and the recommended action plan for the near term and long term. The report also provides several important documents in its appendices such as a description of the technical visits to industrial facilities, a list of workshop participants and contributors, and finally, a TAA template.

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OVERVIEW

This report of the FBW09 Workshop is intended to give the reader a comprehensive view of the discussions and findings that took place during the workshop, and serve as a reference guide for one to delve into the world of fly-by-wireless technology and the challenges and opportunities it offers for aerospace applications. This document also defines the mechanism of the CANEUS FBW consortium among the four others (Small Satellites, Aerospace Reliability, Devices, and Materials) and its project framework.

The first chapter covering the overview and raison d'être of the FBW consortium lays the groundwork for the report itself as it describes the mission, vision, and goals of the consortium and the CANEUS organisation as well. The second chapter builds on this and lays out the FBW consortium's framework for IP and regulatory compliance. The sessions covered in this chapter provided an outline of the correlation between technology creation, business and intellectual property.

The third chapter moves into the domain of end-user needs; and more specifically the needs of the aeronautics, space, and defence sectors. Each section describes the problems and needs identified by the end-users, followed by the current approaches, the applications discussed, the challenges and issues faced, and finally stakeholder involvement. The tech-provider briefings of day two of the workshop are covered in chapter four under the heading of "current technological developments". Each section covers the presentations made by tech-providers, describes the technology itself, applications involved, stakeholders involved, and other key relevant application areas.

The fifth chapter then summarizes funding and success criteria for project development and focuses on funding mechanisms for the following: universities, commercial sector, risk management, and prototype demonstration. Chapter six forms the core of the report and describes the four projects that emerged from the workshop as well as their implementation approach.

And finally, this report concludes by reflecting on the various challenges encountered as well as key issues that face the aerospace industry and the infusion of FBW technology. Furthermore, a concrete action plan with specific timelines (near and long term), recommended steps for future work and some concluding remarks address those challenges.

WORKSHOP GOALS

The CANEUS FBW09 Workshop program was built on: (a) the vision, mission and goals defined at the 1st CANEUS/NASA Fly-by-Wireless Workshop held in March 2007 and (b)focus projects that were proposed and formulated at the Fly-By-Wireless Sector Consortium sessions held at the CANEUS 2009 workshop at NASA Ames on March 1-6, 2009. The goals of the FBW09 Workshop were to significantly advance each of the CANEUS Sector Consortia by creating their roadmaps and articulating well-defined projects for the aerospace industry.

The core premise of this 2nd CANEUS FBW09 Workshop was for complementary skill sets from across several organizations and countries are needed to rapidly and cost-effectively transform emerging FBW concepts into practical Aerospace systems. The workshop culminated in measurable deliverables, namely a set of project "blueprints", for developing the most promising concepts to system-level prototypes.

Therefore, the 2nd CANEUS Fly-by-Wireless workshop aims included: (a) refinement of the focus projects and pertinent details, identification of specific development needs, outlining of teaming and funding schemes, planning of project oversight and execution, and establishment of milestones from which to gauge success of the projects, and (b) stimulation of project team formation, comprised of technology providers and application/end users and project proposals from each team having significant mutual benefits and high potential of funding from internal or external organizations.

SUMMARY OF THE SESSIONS

Overview and Raison d'être of the FBW Consortium

The session consisted of an overview of the CANEUS innovation model, its mission, vision, and goals. Speakers provided participants with the raison d'être of FBW consortia including: the process for launching Sector Consortia and projects within the CANEUS innovation framework, and the approach for FBW Consortia to implement its roadmaps, covering end-user needs, technology assessment, success metrics; IP and the funding mechanism involved.

FBW Consortium Framework: IP, and Regulatory Compliance

This session provided an overview of the issues associated with intellectual property, enabling participants of the CANEUS FBW09 Workshop to understand the interrelationship of business creation, technology creation and intellectual property. In addition to this, the panel discussed how this foundation interrelates with the CANEUS IP model for CANEUS Collaborative Project Implementation.

The focus of the "Project Charter Agreement and Export Control Policy Panel" was to debate and determine the pros and cons of issues related to the emerging technology opportunities and obstacles for taking potential concepts to product / system level so that Canada, U.S., Europe and other foreign policy-makers may make well-informed judgments concerning the formation and implementation of pertinent policy decisions in these fields.

End-User Needs and Lessons Learned (Aeronautics, Space and Defense)

This session reviewed the needs of the aerospace industry in manned space, unmanned space, aeronautics, defense, and reliability, as well as the lessons learned in space, aeronautics, and defense. Projects identified in Sector Consortia Development incorporated the needs and the lessons learned from these sectors.

Current Technological Developments

These sessions reviewed the state-of-the-art and technology breakthroughs being made worldwide that can reduce aerospace cabling. For example, Surface Acoustic Wave (SAW) sensors are making their commercial debut in temperature and pressure applications. Low power, adaptive, and robust radio technologies and systems are being used for important wireless applications in several Space Agency programs. Some aircraft now have FAA-approved wireless devices, e.g. a breakthrough has produced a no-power sensor-tag system that can collect data from a variety of common sensors and switches at distances useable for aerospace vehicle applications.

Speakers discussed exciting developments from their own organizations to meet the challenging requirements of next generation aircraft and spacecraft applications. Each speaker presented recent advances in his/her organization within the context of potential collaborative projects, to a proof-of-principle level of maturity, and speculated on the path and timeframe for future system- level development.

Funding and Project Success Criteria

These sessions were at the heart of this workshop and addressed project development, funding mechanism, implementation, and international collaboration issues. The solutions offered in these sessions are expected to guide participants in the implementation process of their projects. Participants produced measurable deliverables to advance the goals and activities of each of the existing well-defined projects as well identify new projects with strong business case.

WORKSHOP OUTCOME

The workshop culminated in measurable deliverables, namely a set of four projects with significant mutual benefits and high funding potential. These four projects include:

wi SENSE

Wireless passive acoustic emission sensors for structural and spacecraft health monitoring will be developed by the Wi-SENSE Project Consortium as part of the CANEUS FBW Consortia.

Project Leader: David Russel, FRL, NRC

wi ISHM

A second project, “Wi- ISHM” by the Wi-SENSE consortium will focus on the in-situ SHM of thick laminate composite structures.

Project Leader: William (Cy) Wilson, NASA Langley Research Center

wi TESTBED

Wireless testbeds to evaluate protocols for critical communications with airborne applications, will be developed by the Wi-TESTBED Project Consortium as part of the CANEUS FBW Consortia.

Project Leader: Douglas Goodman, Ridgetop Group Inc.

wi ENGINE

Wireless Sensor System for Engine Monitoring will be developed by the Wi-ENGINE Project Consortium as part of the CANEUS FBW Consortia.

Project Leader: Mourad El-Gamal, McGill University, MEMS Vision Inc.

Introduction

FLY-BY-WIRELESS BACKGROUND

There are many limitations and impacts of wired connectivity on aerospace vehicles, government programs, and the aerospace industry worldwide. The technical challenge is to reduce the wired connectivity for aerospace vehicle architectures and systems by providing reliable "less wire" and wireless technology alternatives as well as vehicle provisions to take advantage of them as the technology maturity and availability increases. Depending on the application, some of these issues might include dynamic and possibly unlimited boundary conditions that alter the propagation channel, greater susceptibility to electromagnetic interference and jamming signals, synchronization issues, less security, power limitations, troubleshooting, and, typically, a requirement for increased propagation space.

Although the performance bounds and limitations of wires are very well known, the ultimate limitations of wireless and "less wire" technologies, in the context of reducing wire weight in critical onboard applications, have not been established. Because of the potential of wireless and "less-wire" technologies to reduce vehicle wire weight, it is important to fully understand these limitations. This workshop fosters the widespread collaboration and cross-pollination of ideas that are necessary to reach that understanding. It also assembles end-users, who are provided the opportunity to disseminate critical requirements and needs, and providers, who are afforded an audience of potential clients as well as a vision of an emerging market.

Kenneth Porad, RFID Program Manager of BOEING delivering a presentation at the first CANEUS Fly-By-Wireless Workshop

PREVIOUS FBW WORKSHOPS

CANEUS/NASA Fly-By-Wireless Workshop for Aerospace Applications
March 27-28, 2007

On March 27th 2007, NASA and CANEUS teamed together to hold the first "Fly-by-Wireless" Workshop in conjunction with the RFID World 2007 Conference and the IEEE International Conference on RFID 2007. The overall goal of this initiative included:

i. To establish an international forum through the CANEUS Organization to exchange public and published information on applications and technology alternatives to wires, which precipitate cooperation and partnerships between industry/government customers, system innovators and technology developers.

ii. To promote the understanding of the capability, maturity and challenges of alternatives to wired infrastructures enabling technologies in order to facilitate timely regulatory and programmatic changes, vehicle architecture accommodations and prioritization of technology development.

iii. To enable key partnerships between End Users and technology providers on an individual and working group level.

iv. To formulate working groups from participants with common interests to identify and clarify their key common interests and formulate forward planning and potential projects. Life-cycle return on investment, Safety, Security and Mission Success are other primary drivers for working together. Leadership, purpose, and products are key initial objectives.

v. Identify and enable proposed CANEUS FBW Projects by both participating CANEUS members and outside organizations.

As a result of this CANEUS/NASA led initiative, many U.S. and international organizations, those participated in the 2007 workshop, have taken steps to continue development of their wireless programs and some teaming has resulted. Many have committed to participation in future Fly-by-Wireless (FBW) working groups, and projects, including EADS, ESA, NASA IPP, and Aviation Safety Program. Meanwhile, many needs have been recently identified in the NASA Constellation Program technology assessments.

Fly-By-Wireless Sector Consortium Sessions at the CANEUS 2009 Workshop, NASA Ames
March 1-6, 2009

The goal of the CANEUS 2009 Workshops was to significantly advance each of the CANEUS Sector Consortia by creating their roadmaps and articulating well-defined projects for the aerospace industry.

The workshop identified a set of project "blueprints" for developing the most promising concepts to system-level prototypes. One of the focus projects that were defined at the NASA Ames Workshop deals with wireless implementation for structural health monitoring of the main fuselage. Such a focused project, with well defined scope for a complete system solution, is supported by all stake holders including the customers and end users, and also entails a portfolio of technology requirements. It will further apply aspects of previously defined technology roadmaps from international agencies.

THE FLY-BY-WIRELESS 2009 WORKSHOP

Fly-by-Wireless 2009 Workshop
June 8-12, 2009

The FBW09 workshop was held at the École Polytechnique on June 8th through the 12th 2009, in Montreal, Canada and drew over 100 participants, which included industry experts, tech providers, end-users, and funding agencies. Day one and two consisted of presentations, round-table discussions, and question-answer sessions. Day three followed the same format and focused more on actual project development. The sessions were based on end-user briefings, tech-provider briefings and then finally project development, implementation, and project success criteria. Day three culminated in the breakout sessions for the project identification process. Participants were divided into three breakout teams and included:

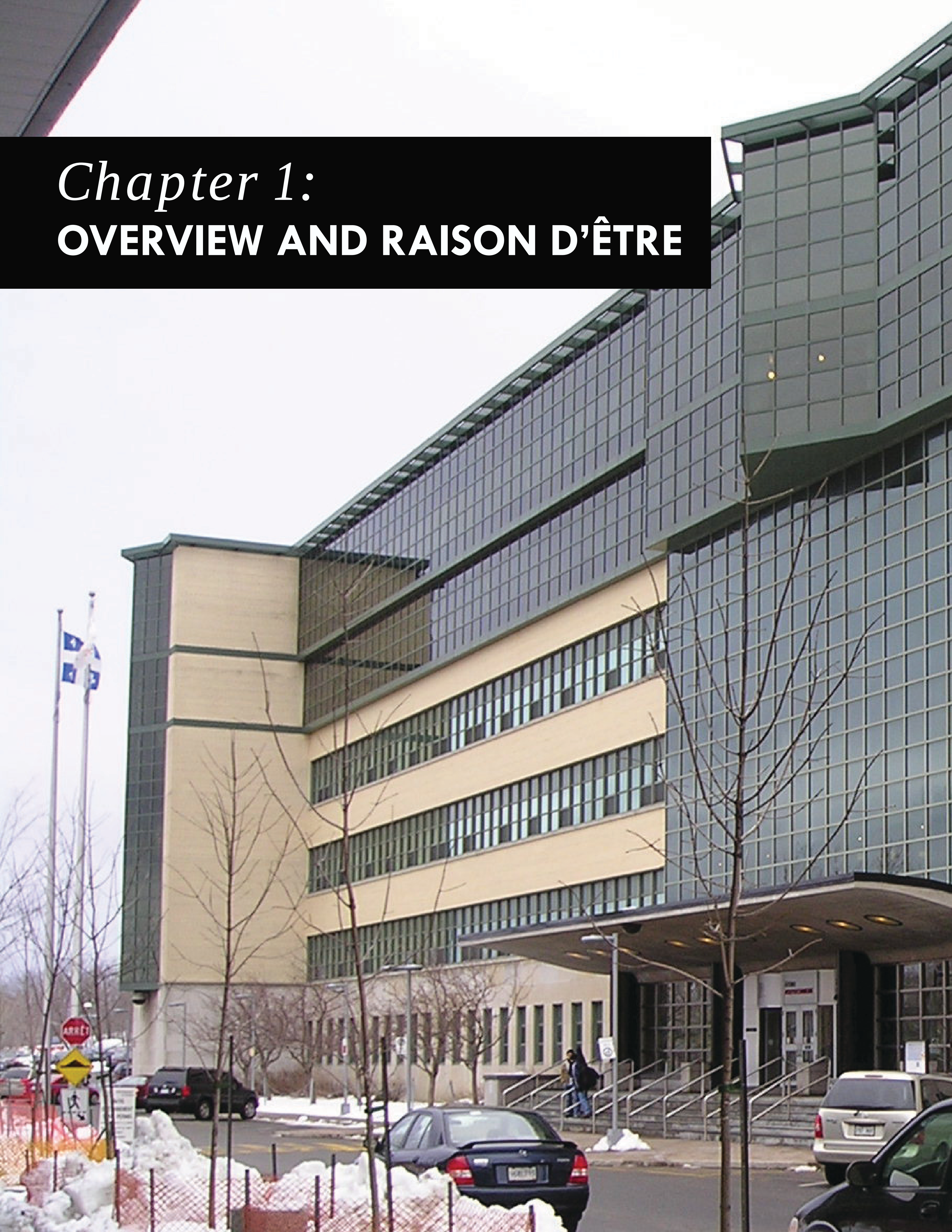
1. Wireless testbed to evaluate protocols for critical communications with airborne applications
2. Wireless passive acoustic emission sensors for structural and spacecraft health monitoring
3. Scalable wireless temperature and pressure monitoring for turbine engine applications

Dr. Robert S. Walker, Assistant Deputy Minister, (Science & Technology) Department of National Defence and Chief Executive Officer Defence, R&D Canada

The objectives of each team were to identify and discuss the following:

i. Expressed needs and current problems
ii. Reasons for the project
iii. Critical success factors
iv. Relevant stakeholders
v. Technologies involved
vi. Goals for providing solutions
vii. Division of work approach
viii. Tasking
ix. Funding requirements
x. Near-term actionable items

Chapter 1: OVERVIEW AND RAISON D'ÊTRE



CHAIR AND CO-CHAIRS

- Jules O'Shea, Professor, École Polytechnique de Montreal
- Roy Vestrum, Flight Research Laboratory, Institute of Aerospace Research, National Research Council Canada
- Andre Bazergui, P-DG/CEO, CRIAQ, Consortium for Research and Innovation in Aerospace in Quebec

SPEAKERS

- Christophe Guy, Director, École Polytechnique de Montreal
- Suzanne Benoit, CEO, Aéro Montreal
- Milind Pimprikar, Founder & Chairman, CANEUS International
- Rick Earles, Executive Director, CANEUS USA Inc.
- Todd Farrar, Business Acceleration Manager, Dawnbreaker, Inc., NY
- David Russel, IAR-NRC

AEROSPACE INDUSTRY AND CANEUS[1]

The aerospace industry in Canada is composed of leading manufacturers, subcontractors, suppliers, research centers, and educational institutions that train some of the most skilled workforce in the world. The Quebec aerospace sector within Canada ranks as the fifth largest in the world in terms of sales after the United States, the UK, France, and Germany. Moreover, Montreal is one of the rare places in the world where practically all the components for a new aircraft can be found within a thirty kilometre radius. As such, Montreal is clearly positioned as the hub of the aerospace sector and CANEUS's prime location within the center of this buzzing city adds incredible advantages.

CANEUS INTERNATIONAL–MISSION, VISION, AND GOALS[2]

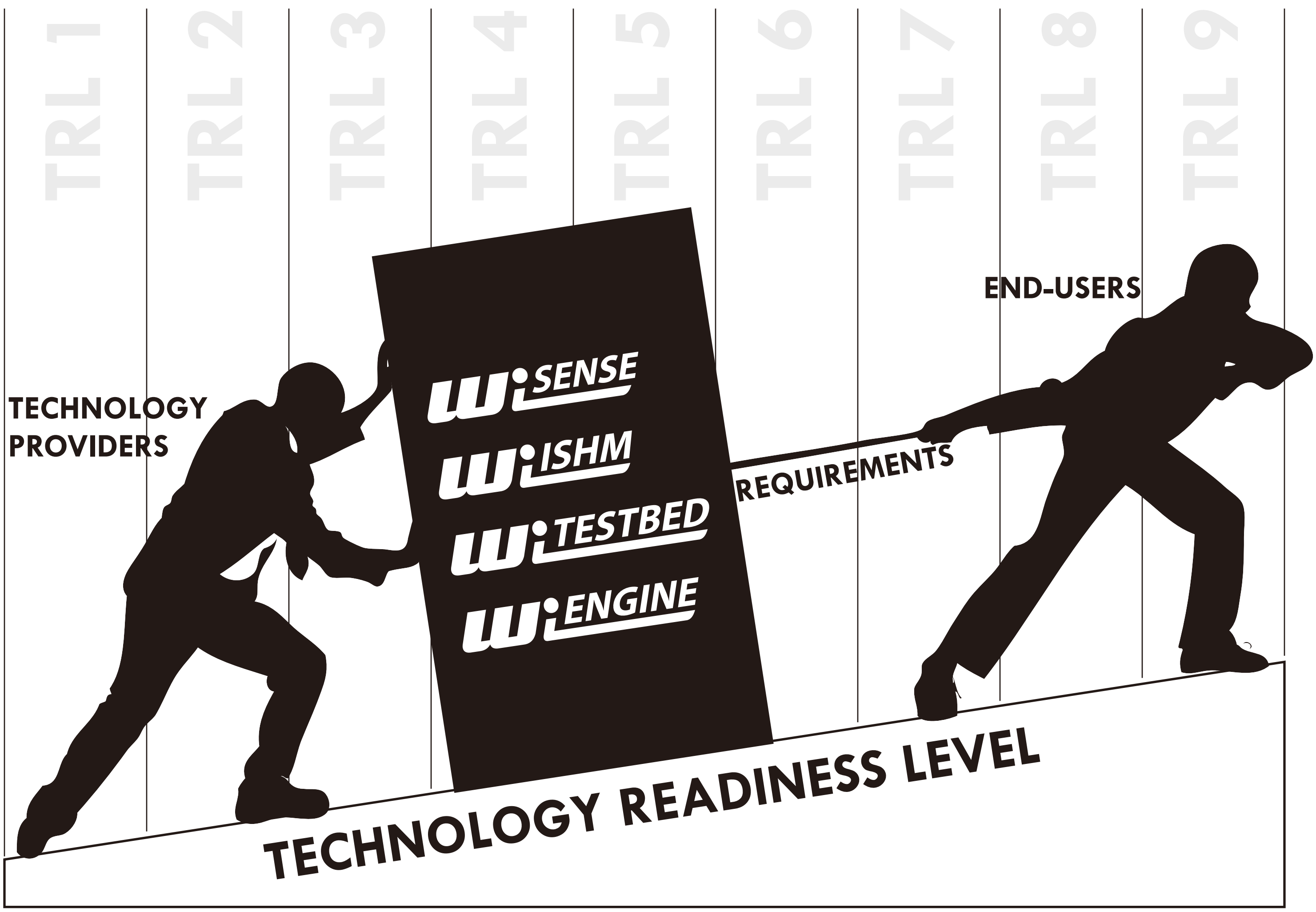
The opening session began with an overview of the CANEUS International Organization. Essentially, CANEUS International is a non-profit organization that seeks to benefit the aerospace industry by fostering international public/private partnerships between industries, research laboratories, and government stakeholders. CANEUS aims to mitigate the high cost and risk of micro-nano technology development by defining and executing these projects and initiatives through collaborative partnerships.

The CANEUS **mission** is to rapidly and cost-effectively bridge the mid-TRL "Valley of Death" for transitioning emerging micro-nano technologies to aerospace systems. The vision is for CANEUS to become the "Virtual World Aerospace Organization" and be recognized for its excellence in providing high return on investment for its stakeholders, through the creation of international consortia that accelerate the development and use of MNT in the aerospace industry. Sector Consortia will thus constitute smoothly functioning development pipelines for emerging technology concepts. CANEUS currently coordinates Sector Consortia dedicated to Small Satellites, Reliability, Fly-By-Wireless (with Structural Vehicle Health Monitoring, Less-Wire Technology, Sensor DAQ and Passive Sensor TAG Systems), Devices (with Harsh Environment Sensors, Photonics, Environmental Monitoring, and Bio-Astra), and Materials (with Micro-Energetics).

The **goals** of the CANEUS Organization are to provide a platform for the coordinated investment and development of emerging MNT concepts by identifying and nurturing complementary core competencies within government, private sector and academic organizations from among the CANEUS member countries; as well as to implement the coordinated investment/development strategy through cost-effective means and mechanisms for the rapid infusion of new MNT-based devices and systems for aerospace and defense applications; and finally, to provide a forum by holding several workshops and conferences for the dissemination of technical and programmatic development and infusion of MNT-based concepts into aerospace applications.

VALUE AND ROLE OF CANEUS[3]

The CANEUS role is to assist by creating a systematic framework within which new projects can be created, reviewed, and approved. The framework is similar to that used by most organisations with one significant difference. Once a peer-reviewed MNT system-development project has been approved, the CANEUS organization becomes actively involved in "shepherding" the project through its various life-cycle phases with the close involvement of both the financial sponsors and the end-customers. CANEUS strongly believes that such an intimate collaboration between all the stakeholders is necessary right from the inception of the project in order to ensure the ultimate success in transitioning MNT concepts to the aerospace system level. Among the various project development resources provided by CANEUS are the following: Quad Chart Wizard, Project Concept Proposal format, and a detailed project plan. Other areas where CANEUS plays a significant role is in cost and risk mitigation, facilitating the total continuum of innovation from concept to technology insertion and market deployment, and establishing funding programs. The organization will also aid in other project milestones such as orchestrating the Project Charter Agreement, the export-control mechanism, and providing an Intellectual Property framework (through the



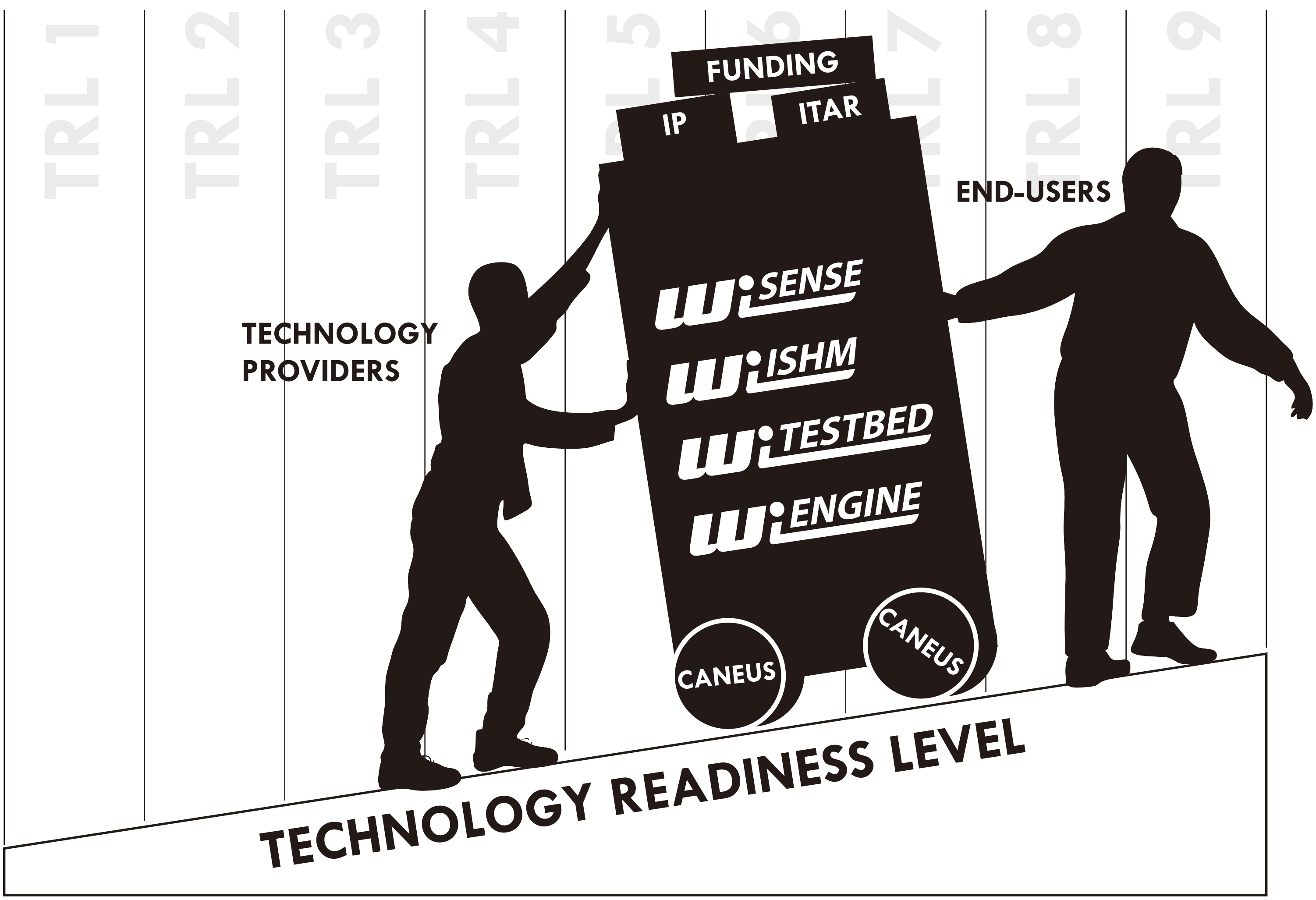
CANEUS IP model).The intention is to develop and share a vision and facilitate progress through cooperation and partnerships across CANEUS regions.

ABOUT THE FBW CONSORTIA[4]

The session provided participants with the raison d'être of the CANEUS FBW consortia including: the process for launching sector consortia and projects within the CANEUS innovation framework, and the approach for FBW Consortia to implement its roadmaps, covering end-user needs, technology assessment, success metrics; IP and the funding mechanism involved.

i. Vision of the FBW Consortia

The CANEUS Fly-by-Wireless Sector Consortium is chartered with precipitating cooperation and partnerships between industry/government customers, system integrators, and technology developers, while exchanging public and published information on wireless alternatives and new innovations, such as no-power sensor-tag systems. Ultimately, the Con-sortium's efforts will contribute to minimizing cables and connectors and increase functionality across the aerospace industry by providing reliable, lower cost, modular and higher performance alternatives to wired data connectivity to benefit the entire vehicle/program life-cycle.



Aerospace vehicle programs have always relied on the cables and connectors to provide power, grounding, data and time synchronization throughout a vehicle's life-cycle. Even with numerous improvements, wiring and connector problems and sensors continue to be key failure points, causing many hours of troubleshooting and replacement. Costly flight delays have been precipitated by the need to troubleshoot cables/connections and add or repair a sensor. Even with the weight penalties, wiring continues to be too expensive to remove once it is installed. Miles of test instrumentation and low flight sensor wires still plague the Aerospace industry. New technology options for data connectivity, processing and micro/nano manufacturing are making it possible to retrofit existing vehicles like the Space Shuttle. New vehicles can now develop architectures that provide for and take advantage of alternate connectivity to wires.

ii. Objectives of the FBW Consortia

The mission of the FBW Consortium is therefore to:

- Increase use of MEMS and Nano Technologies
- Ensure technology reliability, increase value and lower the cost
- Set global direction to yield significant ROI
- Promote alternatives to wired infrastructure; such as no-power instrumentation, standalone wireless data acquisition and processing systems, and wireless control redundancy improvements, in order to facilitate timely vehicle architecture accommodations and prioritize technology development;
- Identify solution paths for key challenges
- Quantify life cycle (ROI) return on investment
- Enable key partnerships towards implementation
- Increase maturity of wireless technologies
- Reduce wires and connectors

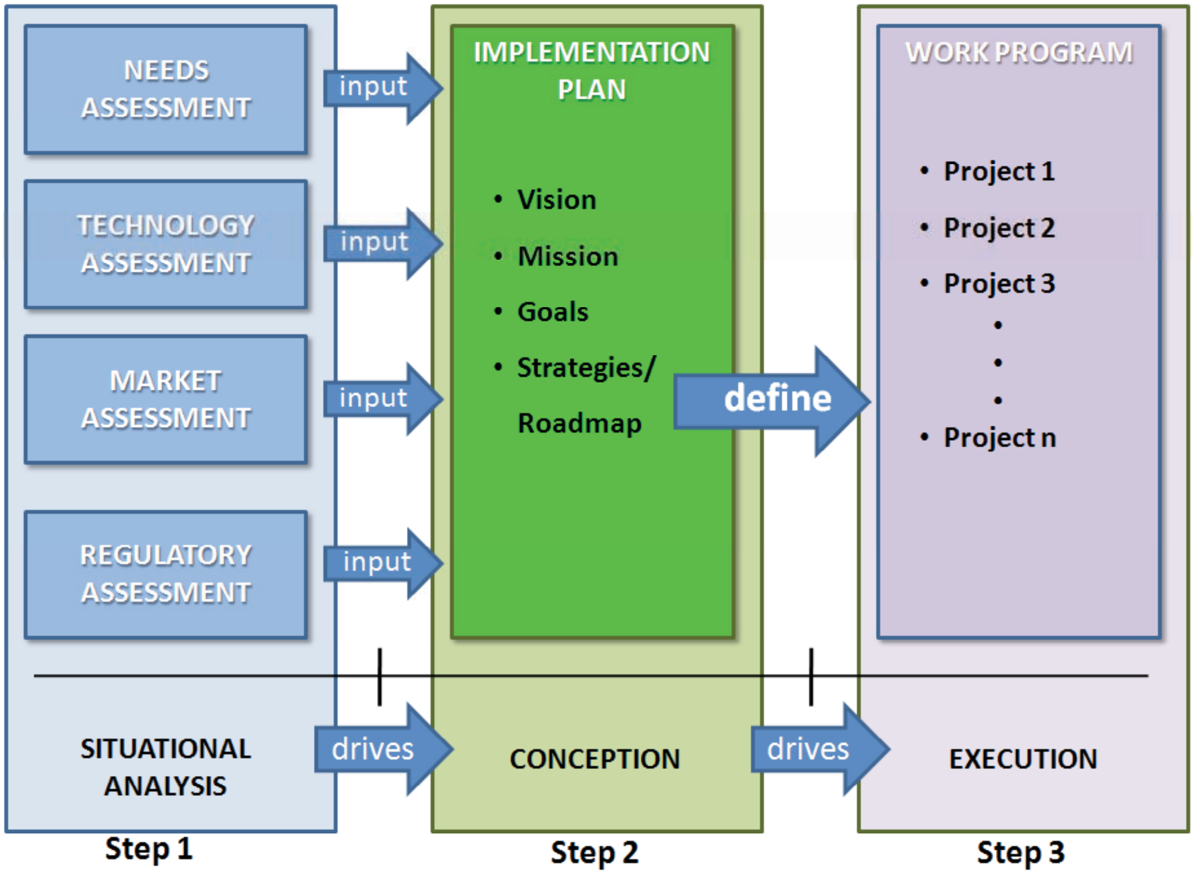
Finally, the opening session also covered the the expected outcomes from the workshop and how the overall workshop objective of well defined and funded projects relates to the activities from days one to three, as well as accomplishments from the CANEUS 2009 Workshop at NASA's Ames Research Center in March 2009; and an overview of five areas: Sensor DAQ Micro-Miniaturization, Passive Wireless Sensor Tag, Less–Wire Architectures, Structural Health Monitoring, Wireless systems immunity in Electromagnetic Environment (HIRF, Lightning etc).

iii. Technological Challenges for FBW

There are many issues associated with onboard wireless that must be addressed in order to enable its widespread acceptance for critical applications. Depending on the application, some of these issues might include dynamic and possibly unlimited boundary conditions that alter the propagation channel, greater susceptibility to electromagnetic interference and jamming signals, synchronization issues, less security, power limitations, troubleshooting, and, typically, a requirement for increased propagation space.

Although the performance bounds and limitations of wires are very well known, the ultimate limitations of wireless and "less wire" technologies, in the context of reducing wire weight in critical onboard applications, have not been established. Because of the potential of wireless and "less-wire" technologies to reduce vehicle wire weight, it is important to fully understand these limitations. This workshop fosters the widespread collaboration and cross-pollination of ideas that are necessary to reach that understanding. It also assembles end-users, who are provided the opportunity to disseminate critical requirements and needs, and providers, who are afforded an audience of potential clients as well as a vision of an emerging market.

Figure 1. CANEUS 2009 Planning Process



WORKSHOP PROCESS[5]

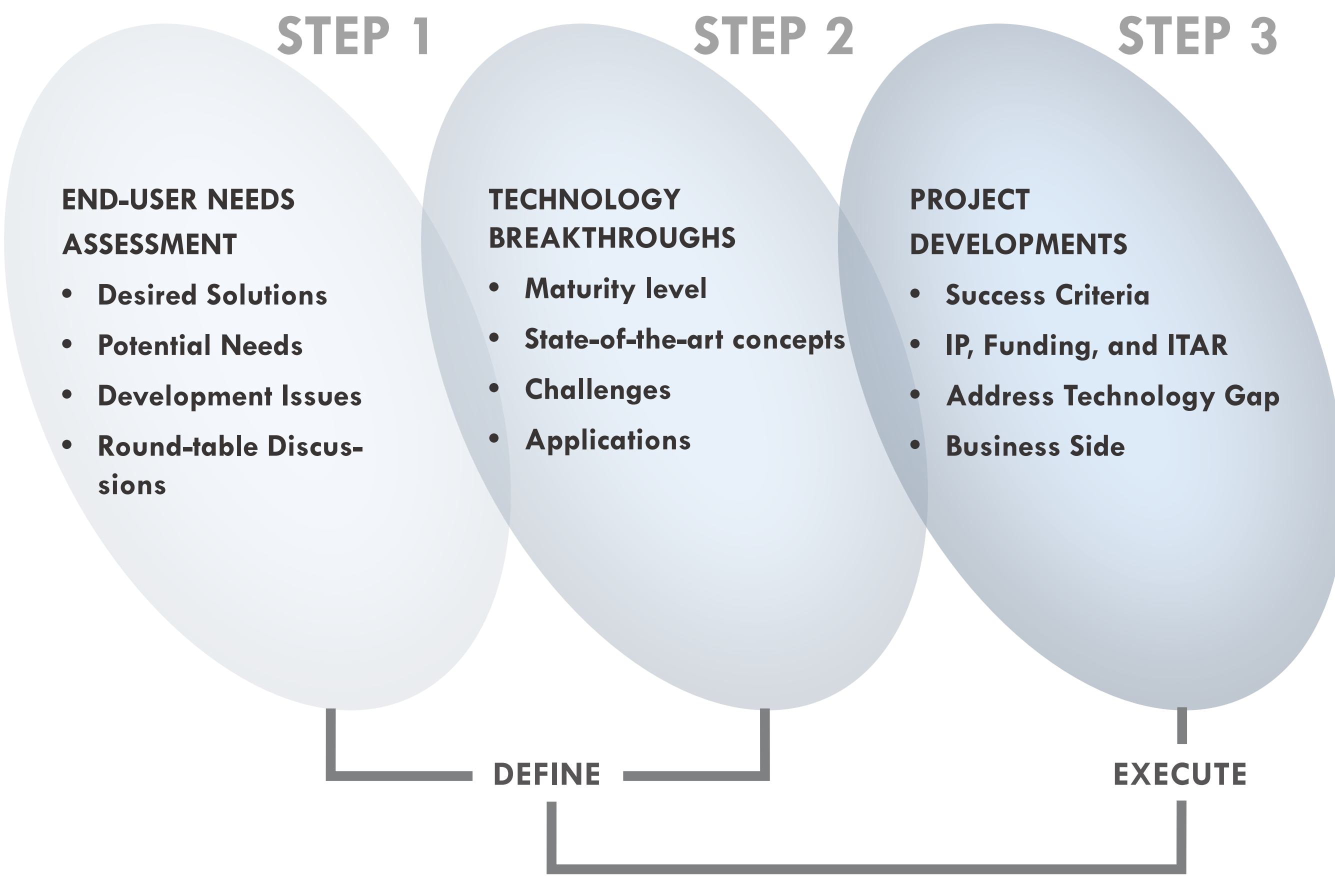
Day1: Plenary and End-User Briefings

At the end of the day, participants gained a clear understanding of the CANEUS vision, mission, and goals, the raison d'être of FBW consortia, project developments from past meetings, relevant funding, IP, and regulatory considerations, and a clear understanding of end-user and customer needs as related to: Structural Health Monitoring / Passive Wireless Sensor Tag / Sensor DAQ Micro-Miniaturization / EMC- HIRF and project concepts or ideas from end-users that could offer potential solutions for identified needs.

Day 2: Technology Provider Briefings

The Day 2 of the workshop presentations focused on "technology assessment" and provided participants with information on: current technology and project developments of relevant Fly By Wireless technology providers, maturity level of current technology developments, and state-of-the art or bleeding-edge technology concepts. Speakers discussed exciting developments from their own organizations to meet the challenging requirements of next generation aircraft and spacecraft applications. For example, each speaker presented recent advances in his/her organization within the context of potential collaborative projects, to a proof-of-principle level of maturity, and speculate on the path and timeframe for future system-level development.

Figure 2. FBW09 Worksop Process



Day3: Project Development, Implementation and Success Criteria

The third day of the workshop discussed: the goals and activities of each of the existing well-defined projects as well as identifying new projects with a strong business case, the priorities of government programs to fund and procure relevant FBW projects and technology developments, selection criteria, metrics for assessment, project duration expectations, and transition or infusion strategies for these types of aerospace funding initiatives, and finally, cross agency and international organization core competencies in developing new technology concepts to a proof-of-concept maturity level.

REFERENCES

1. "Aero Montreal", http://www.aeromontreal.ca
2. "CANEUS International", www.caneus.org
3. "CANEUS International", www.caneus.org
4. "Fly By Wireless Sector Consortia", www.caneus.org/fbw
5. CANEUS Fly-By-Wireless 2009 Workshop Handbook pp. 5-11

Chapter 2:

CONSORTIUM ISSUES: IP, PROJECT CHARTER AGREEMENT, AND REGULATORY COMPLIANCE

CHAIR AND CO-CHAIRS

- Wanping Zheng, Canadian Space Agency

SPEAKERS

- George N. Grammas, Partner, Squire, Sanders & Dempsey L.L.P. Washington, DC
- Rick Earles, Executive Director, CANEUS USA Inc.

OVERVIEW

These sessions provided an overview of the issues associated with intellectual property, enabling participants of the CANEUS FBW09 Workshop to understand the interrelationship of business creation, technology creation and intellectual property. In addition to this, the panel discussed how this foundation interrelates with the CANEUS IP model for CANEUS Collaborative Project Implementation. These sessions also addressed project development, implementation, and international collaboration issues. The solutions offered in these sessions guided partici-pants in the implementation process of their projects.

CANEUS has endeavoured to create a program that optimizes the use of participant time to produce measurable deliverables to advance the goals and activities of each of the existing well-defined projects as well as identify new projects with a strong business case.

CANEUS IP FRAMEWORK[1]

The session on IP framework served first, to provide a review of the essential elements of the CANEUS intellectual property framework using specific collaboration examples. Second, to discuss this IP model as compared to those from other Consortia models in terms of their applicability to the needs of the CANEUS FBW09 program and then to agree on an IP model for CANEUS Collaborative Projects Implementation. And third, to discuss intellectual property issues, which will affect the implementation of the CANEUS Consortia Projects.

> *"...review of the essential elements of the CANEUS intellectual property framework using specific collaboration examples."*

Objectives, Issues, and Solutions

By recognizing the somewhat unique requirements of the university, industry and government constituencies, independently and as a collective whole, the goals of the CANEUS IP framework are:

Firstly, to facilitate the commercialization of results from CANEUS project collaboration and to create incentives for active commercial development, job creation and aerospace industry expansion. Secondly, to provide incentives for participants to pursue collaborative research and development, leveraging the unique facilities and skills of the CANEUS network to obtain commercial applications for the economic benefit of themselves, and the industry. And finally, to provide for an equitable sharing of rewards from commercialization among those that contribute to the invention of MNT related products or services.

Essentially, each party owns title to the intellectual contribution they make to the Project development. However, whenever possible, ownership of Jointly Developed IP will be assigned to a single party especially in those instances where the IP plays a minor role in the other Project team members' businesses. CANEUS projects involve both pre-competitive and proprietary technology development with the terms of ownership and licensing supporting a supply chain theme that recognizes the role of an end user, system integrator, and suppliers in the distribution of rights to the IP.

Systems integrators that typically have the responsibility for a system solution comprised of a portfolio of Project developments must have enough control of the IP to protect the resulting product from competitive encroachment. As such, supply partners must be prepared to provide exclusive niche market licenses for uniquely configured technologies.

The valuation of IP (background and foreground) and licensing terms associated with a Project is determined prior to Project start and said terms are established for final Project approval. Total royalties are then capped at a percent of the sell price of the product or process that result from the Project and the Project team agree on the percentage cap prior to Project start. Intellectual property associated with a particular Project will thus be contained in a Project Teaming Agreement that is then negotiated and signed by all the project team members prior to project start.

When necessary, CANEUS also plays the role of broker to streamline the technology transfer process in order to accommodate needs of the others who are interested and to maximize the value of technology in other non-aerospace niche market opportunities.

PROJECT CHARTER AGREEMENT AND TAA[2]

The objective of the Project Charter Agreement session was to debate and determine the pros and cons of issues related to the emerging technology opportunities and obstacles for taking potential concepts to the product / system level so that Canada, U.S., Europe and other foreign policy-makers may make well-informed judgments concerning the formation and implementation of pertinent policy decisions in these fields.

Project Charter Agreement itself refines the scope, the NDA, and the TAA.

Some discussion points included; the CANEUS ITAR framework for the infusion of emerging technology-based systems into Aerospace applications, discuss the draft "Project Charter Agreement", discuss how the current agreements can be amended in order for new partners to join the consortium and to implement these collaborative projects.

The purpose of the TAA is to allow parties to collaborate on the development of standards, definitions and specifications for Fly-By-Wireless solutions to be used in spacecraft applications by or for end-users. MNT technology and possible Fly-By-Wireless solutions are at an early stage of technology readiness. A variety of potential applications are expected to surface beyond use in the space program. For example, parties can intend to specify that the standards, definitions and specifications for Fly-By-Wireless solutions will be used or adapted for use in civilian aerospace applications.

INTERNATIONAL EXPORT CONTROL / ITAR REGULATIONS[3]

With regards to the technology governed by ITAR[4], participants gained a clearer picture of certain ITAR indicators such as: origins of technology (military or space), funding for development (military or space agency), purpose for design and development (military or space). It was also discussed that the application of export controls depends on:

the place of export, nationality of the exporter, origin of the goods and/or technology being exported, and may also be subject to the local country's export controls. The transmission of technical data consists of: sending technical data recorded or stored in any physical form, sending via fax or email, access by websites, telephone calls, and disclosing technical data, including visual or oral access to technical data, to a Foreign Person in the United States (ie. "deemed export"). And finally, participants learned about when an export license is required; which depends on several things. If under the EAR, it is dependent on the sensitivity/nature of the technology and destination of export (or home country of foreign employee). When under the ITAR – a license is almost always required when technical data is to be disclosed to a Foreign Person.

Issues and Solutions

Issues and questions addressed during the session included:

- When is technology governed by ITAR?
- What does the application of export controls depend on?
- What Constitutes An Export Of Technical Data? And what is "Technical Data?"
- Terminology such as: what is a "Deemed Export", "Foreign Person", "Home Country"?
- When is an export license required?

REFERENCES

1. CANEUS Fly-By-Wireless 09 Workshop Handbook, pg. 48.
2. "Technical Assistance Agreement Template", Appendix G
3. CANEUS Fly-By-Wireless 09 Workshop Program, pg. 18
4. CANEUS ITAR Handbook

Chapter 3:
END-USER NEEDS

(Aeronautics, Space, and Defense)

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- Yvon Savaria, Chairman, Electrical Engineering, École Polytechnique de Montreal
- Patrice Masson, Professor, University of Sherbrooke
- Claude Lavoie, Bombardier Aerospace

SPEAKERS

- Robert S. Walker, Assistant Deputy Minister and CEO, DRDC-DND (Defense Research and Development Canada- Dept. of National Defense)
- Radoslaw R. Zakrzewski, Sensors and Integrated Systems, Goodrich Corporation, USA
- Victor Giurgiutiu, Structural Mechanics program manager, Air Force Office of Scientific Research (AFOSR)
- William "Cy" Wilson, NASA Langley Research Centre, Virginia
- Hugh HT Liu, Institute for Aerospace Studies University of Toronto
- Nezih Mrad, Defence Scientist, Defence R&D Canada (DRDC), Department of National Defence (DND)
- Fidele Moupfouma, Chief Aircraft Electromagnetic Hazards Protection Engineer, Bombardier
- Duane Cutrell, F-35 Joint Strike Fighter, LMCO- Skunk Works
- Fassi Kafeyeke Strategic and Technology Director, and Chief Engineer, Bombardier Aerospace

ROUND-TABLE WORKSHOP PARTICIPANTS

- Pratt & Whitney(Parag Bowankar, Jim Jarvo)
- NASA-JPL (Alex Jimenez)
- Embrear (Ricardo Rulli)
- Bombardier (Claude Lavoie)

OVERVIEW[1]

These sessions reviewed the needs of the aerospace industry in manned space, aeronautics, defense, and reliability, as well as the needs and lessons learned.

A. Wireless Systems Immunity in aircraft electromagnetic environment[2]

Author: Fidele Moupfouma

Problem/Needs Discussed:

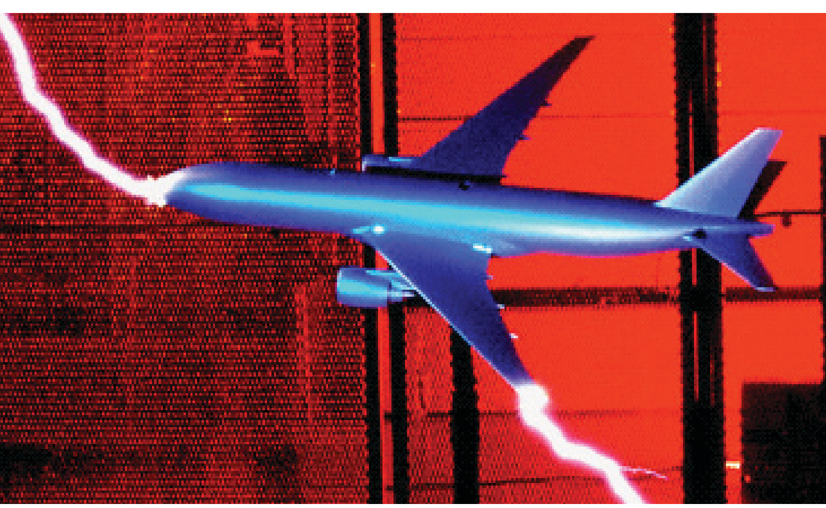
- As electronic systems get smaller they become increasingly sensitive to EM threat
- New aircraft structures will have a reduced amount of conductive structure which increases the susceptibility of bundles to lighting
- Better aircraft structural protection from lightning
- Need to mitigate the effects of increased reflections at various frequencies when transmitted inside of the fuselage
- Risks of intermodulation - several wireless systems could lead to unwanted interactions

Current Approaches:

- Cable shielding
- Need protection at 10MHz - use connectors and shielding - pigtail
- Current cable diagrams will either create interference issues or will consume too much room
- To protect from lighting, 2 layers of shielding is needed/used
- Repeaters are used but do not do a good job of reducing the susceptibility to lightning
- Current approaches are too costly or weigh too much
- Harnesses could collect high lightning induced current and affect systems immunity
- Routing harness can lead to cross talk mounted antenna can be hit by lightning causing flight deck to lose access to critical information

Other Discussion Points:

- Testing - lightning transient analysis (LTA)



B. Structural Health Monitoring and NDE[3]

Author: Victor Girurgiutiu

Problem/Needs Discussed:

The needs identified in the aeronautics session are the following: Multiple crack scales and multiple crack generation, obsolescence of technology, analysis in the presence of variability due to material processing, fabrication, etc., on board health monitoring, prediction of structural flaws, prediction of flight structure Hot Spots, structural sustainment - prediction of structural flaws, on board health monitoring and embedded NDE, prediction of flight structures "hot spots"

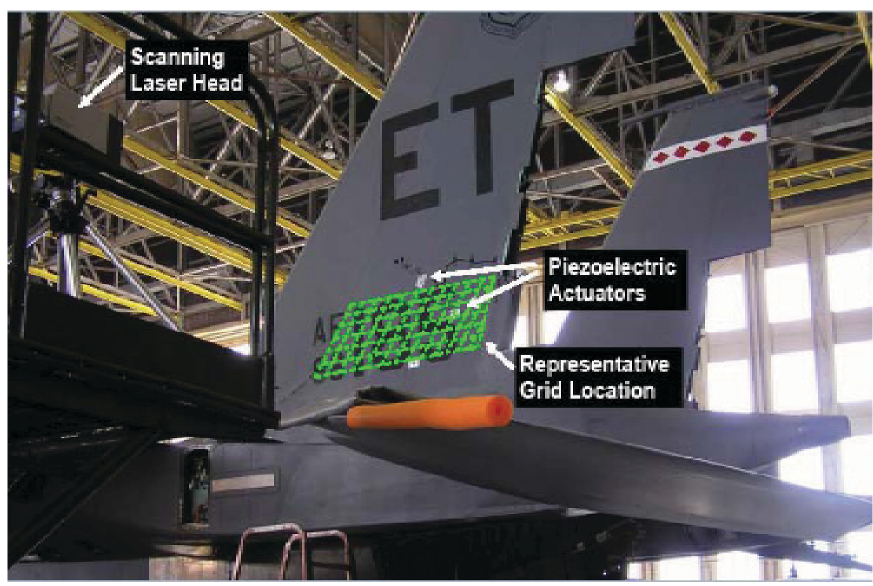
Better ways to predict future behaviour of aircraft through analysis, breaking the barrier for structural analysis, improved sensors, and also improvement of sensor location though the fusion of analysis information.

Current Approaches:

In order to address these needs, it was found that research and science is essential for maintaining air supremacy. Funding basic research relevant to USAF that can be freely shared among the international scientific community would essentially address this issue.

Applications Discussed:

Relevant applications discussed were: micromechanical modeling for structural state awareness (ex: finite element modeling of grain boundaries), novel structural sensing concepts, map strain with wireless, crack growth monitoring, embedded ultrasonic transducers, and multiscale damage detection with laser vibrometer of delamination of composites. Examples include:



- RFID –passive wireless strength sensor
- Syntronics (STTR)
- active sensor arrays – crack growth monitoring with PWAS phased arrays (USC)
- novel embedded ultrasonic transducer - multi directional waves – actually constructed
- multi scale damage detection using laser vibrometer for delaminating
- Millennium Dynamics
- Uncertainty and stochastic prognosis: Bayesian prognosis of damage progress, fatigue variability and implications for life predictions (fatigue strength can vary 3 orders of magnitude)
- UFL & NCSU - probability based treatment of SHM
- AFRL/RXLM – fatigue variability and implications on life prediction (Larsen) modes of failure

C. Protected spectrum for Wireless Avionics Systems[4]

Author: Radoslaw Zakrzewski

Problem/ Needs discussed:

Regulatory protection from unwanted interference is one of the necessary conditions for use of wireless communications in safety-critical aircraft systems.

Current Approaches:

An industry group operating within Aerospace Vehicle Systems Institute has initiated an effort to obtain internationally recognized protected frequency allocations for wireless avionics.

NASA – passive wireless sensors for IVHM/SHM[5]

Author: William Wilson

Problem/Needs Discussed:

During the end-user needs involving the space sector, two essential needs were identified. These included: improvement of the safety of aircraft before leaving the ground, and the need for SAW devices for a variety of applications.

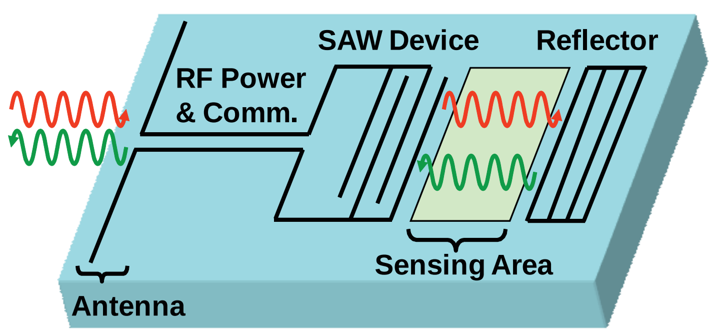
Current Approaches:

Current approaches involve SAW Devices, more specifically devices self powered from RF which are used to make a variety of sensors and are good for passive wireless applications.

Applications Discussed:

The first application discussed was IVHM – for detection, diagnosis, prognosis, damage mitigation, lightning and EMI. Secondly, ground testing for the elimination of cabling for strain gauges used on ground testing with 100-1000 sensors. Others include: wireless sensors within thermal vacuum chamber (vibration and thermal testing need for accelerometers), wireless sensors that can be retrofitted for hard to reach places or for internal placement on complex structures, thermal protection systems – getting more data off of spacecrafts, and finally, sensors for leak detection and structural integrity inflatable habitats.

FOR AIRCRAFTS:
Shape sensing sensors for aircraft wings
AIRCRAFT PROPULSION:
Wireless sensors for operation up to 1200C
HYPERSONIC:
X-43 high temperature sensor & cryogenic temperatures



Project Concept(s):

Some concepts that emerged from this session include: passive wireless sensors or ground testing – strain gauges – integration with DAQS, as well as the search for SAW device developers to help address the needs due to lack of resources.

Issues/Challenges:

Some challenges encountered in the sector relate to the following: power, harsh environments, reduced volume and mass, and RF/Communications.

A. Wireless Technologies For Military Platforms[6]

Author: Nezih Mrad

Problem/Needs Discussed:

Two central issues identified in the defense sector related to the CH149 (Cormorant) and CC130 (Hercules) specifically. The needs identified with regards to the CH149 are the cracking of tail rotor blade brackets and the corrosion of the belly (bay area). For the CC130 (Hercules), the cracking of the wing support cap (which includes fuel tanks) and pressure bulkhead cracking are both problems that were identified as well.

- Other Needs:
- Light weight
- Really small
- Sensor batteries life expectation too low(4.5 hours)
- Frequency range vs noise and power consumption
- Transmitting through wing panel
- Miniaturization
- Cabling and shielding (increase maintenance, fire risk)
- Interoperable with multiple types of sensors
- User friendly
- Programming
- Training for instrumentation and system operation
- Implementation: Economic, Technological, Certification (modification of procedures and manuals)
- Sensitivity to environment interferences'.
- Life cycling (at least 10years expectation)

Current Approaches:

Based on current findings and recent development, the following are examples of approaches designed to address the issues and needs addressed in the preceding paragraph: fiber optic & arrayed waveguide gratings (too big), piezoelectric sensor networks, comparative vacuum monitoring corrosion (wires too big), sensor right on string direct in PCB board, for power energy harvesting from vibrations- current systems are noisy, and the use of energy harvesting to address sensor power issues.

Applications Discussed:

Keeping the previous approaches in mind, some applications brought forth for discussion were: Smart systems that can be in sleep mode most of the time without missing information, sensors on rotating parts, and energy harvesting. When asked to identify the needs by priority, participants recognized that miniaturization and supplying power or saving played the most important roles amongst these priorities.

Stakeholder Involvement:

Defense, air research projects (ARP), multiple universities, and industries are key stakeholders that are involved.

Regulatory Compliance Issues:

EMC-EMI shielding and interference

Project Concept:

A project concept that was discussed and that would benefit from innovations in the field was the Black Hawk concept that compared the cost of a wired system at 230k$ vs. a wireless version at 60k$.

Challenges and Issues:

Problems identified were the following: power (reliable and long term),size, weight, increased cabling and shielding, staff training, ROI, Technological, and Certification (cost vs. benefits?), defense security, efficient DAQ, and the need to think about issues to reduce or optimize power consumption via software, design, etc.

B. Matching Client Needs to Technology Solutions: A Canadian Perspective[7]

Author: Robert S. Walker

Problem/Needs Discussed:

- Global Context and Policy Environment
- Evolving Defence and Security Context
  - Complex Conflict Spectrum
  - Asymmetric Threats
  - Global Economic Crisis
  - Common Security and Defence Agenda
  - Globalization of Science and Technology
- Need to address Defence and Security S&T Hard Problems and Emerging/Disruptive Technologies
- Need for Partnerships and Collaboration
- New aircraft structures will have a reduced amount of conductive structure which increases the susceptibility of bundles to lighting
- Need better aircraft structural protection from lightning
- Need to mitigate the effects of increased reflections at various frequencies when transmitted inside of the fuselage
- Risks of intermodulation - several wireless systems could lead to unwanted interactions

Current Approaches:

- Canada First Defence Strategy: Defence and the Economy
  - Aligning across four pillars:
    - Government-Industry Relationship
      - Early proactive Government-Industry engagement for mutual benefit
    - Procurement Management
      - Responsive procurement strategies, practices and streamlined processes for timely delivery and best value for Canada and Industry
    - Technology Management
      - Aligning the push of R&D investment with the pull of procurement
    - Industrial Policy Management
      - Increased effect of Government policy instruments in support of strategic objectives

- Technology Push-Pull
    - Increased demand for technology to support operations and acquisitions.
    - Increased availability of niche solutions.
    - Increased demand to link the two in an agile and expedient manner.
    - Increased demand to contribute solutions to the global economic crisis.
- DRDC Business Model Features:
    - Management by Business Line
    - Multi-year project management
    - Blend of competitive and directed funding
    - Industry co-investment/co-development
    - Leveraging from international and national partners
- ADM(S&T)/DRDC Business Model: Building the Defence and Security S&T Program:
    - Competition of Ideas
    - Directed Projects
- To ensure the Canadian Forces are technologically prepared and operationally relevant.
- The Evolving Role for DRDC:
    - DRDC as a Risk Mitigator
    - DRDC as a Strategic Advisor
    - DRDC as an S&T Integrator
    - DRDC as an Economic Stimulus
- S&T Investment Priorities:
    - Defence and Security Hard Problems
    - Emerging/Disruptive Technologies
    - Purpose-Built Internal and External Partnerships
- Expectations for S&T Cooperation: a DRDC Perspective
    - Knowledge Development
    - Technology Development

Other Discussion Points:

- **Partnerships are Essential**
  - To increase S&T capacity to support departmental core processes
    - Augment internal capabilities
    - Provide surge capacity when needed
    - Strengthen the Canadian innovation system
  - To shorten fielding times for technology solutions
    - Avoid duplication of effort and unnecessary infrastructure investments
    - Maximize the use of public research funding by leveraging the S&T investment
  - To improve access to global leading-edge S&T advancements
    - Sustain and enhance the quality and impact of R&D within industry, academia and OGD partners
    - Increase exposure to international developments
  - To align with and support the priorities of the Government of Canada and related strategies
    - Canada First Defence Strategy
    - Advantage Canada
    - 2007 Federal Science and Technology Strategy
    - Budget & others

CONCLUSIONS

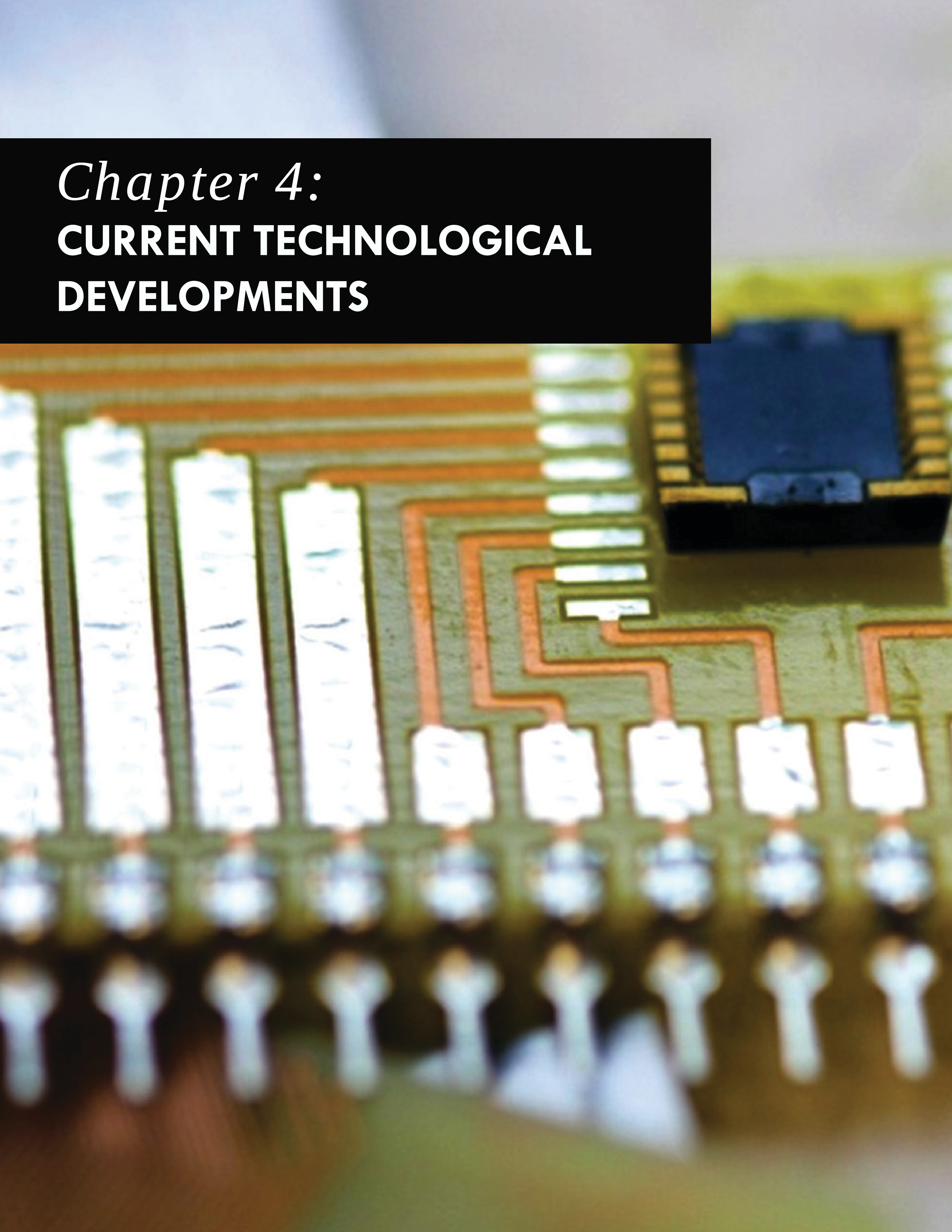
Based on the findings from the end-user sessions, the objective was then to form project teams and project proposals that have significant mutual benefit and high potential of funding from internal or external organizations. Therefore based on the potential applications and ideas for solutions identified on the first day, there emerged several potential project concepts based on these findings:

- Scalable system for wireless temperature and pressure monitoring (in stream) for high temperature turbine engines applications
- Use of waveguides for intra-aircraft wireless transmissions in order to mitigate risks from EMI/HIRF and intermodulation
- Development of standards, tools, and methodologies to reduce vulnerability of wireless nodes to EMP.

REFERENCES

1. CANEUS Fly-By-Wireless 2009 Final Program pp.19-21
2. Moupfouma, Fidele. Wireless Systems Immunity in aircraft electromagnetic environment" FBW09 Presentations, http://caneus.org/fbw/content.aspx?id=resources_2009.
3. Giurgiutiu, Victor."Structural Health Monitoring and NDE", FBW09 Presentations, http://caneus.org/fbw/content.aspx?id=resources_2009
4. Zakrzewski, Radoslaw. "Protected spectrum for Wireless Avionics Systems," FBW09 Presentations, http://caneus.org/fbw/content.aspx?id=resources_2009
5. Wilson, William."Passive wireless sensors for IVHM/SHM," FBW09 Presentations, http://caneus.org/fbw/content.aspx?id=resources_2009
6. Mrad, Nezih. "Wireless Technologies For Military Platforms" FBW09 Presentations. http://caneus.org/fbw/content.aspx?id=resources_2009
7. Robert S. Walker, "Matching Client Needs to Technology Solutions: A Canadian Perspective" FBW09 Presentations, http://caneus.org/fbw/content.aspx?id=resources_2009

Chapter 4: CURRENT TECHNOLOGICAL DEVELOPMENTS



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- Pascal Hubert, McGill University
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- Jureck Sasiadek, Carleton University
- Alain Bolduc, CMC

SPEAKERS

- Fu-Ko Chang, Professor and Director, Structures and Composites Laboratory, Stanford University
- Jacqueline Hines, CEO, Applied Sensor Research & Development Corporation
- Donald C. Malocha, Professor, School of Electrical Engineering, University of Central Florida
- Eamonn Fearon, Centre Manager, Lairdside Laser Engineering Centre,University of Liverpool
- Ahmadreza Tabesh, and Luc G. Frechette, University of Sherbrooke
- Francis Picard, INO (National Optic Institute)
- Radislav A. Potyrailo, Principal Scientist , GE Global Research Center, NY
- Tribikram Kundu, Chairman, SPIE SHM Conferences, University of Arizona
- Cheng-Kuei Jen, IMI (Industrial Materials Institute)
- Carles Ferrer, CNEM (National Center of Microelectronics) Spain
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- Yvon Savaria, Guchuan Zhu, Mohamad Sawan, Normand Bélanger, École Polytechnique de Montréal
- Maurizio Dacunha, University of Maine

OVERVIEW[1]

The goal of the tech-provider sessions was to provide participants with a comprehensive view of the:

- Current technology and project developments of relevant Fly-By-Wireless technology providers
- Maturity level of current technology developments
- State-of-the art or cutting-edge technology concepts

Based on the technology provider briefings, we are able to start identifying synergies amongst the technology providers that can become part of a solution set. The end-user sessions gave a general idea for potential or desired solutions. However, before beginning to work collaboratively to establish projects that would address such solutions, it is vital to understand the current maturity levels of cutting edge technology developments.

I. IMPLEMENTATION FOR STRUCTURAL HEALTH MONITORING[2]	
Author	Fu-Ko Chang
Technology Description:	Smart layer strips: piezoelectric sensor/actuators wired network embedded in a stretchable and flexible polymer matrix. The focus is on denser integration by size reduction into the micro-nanoscale (CMOS technology, carbon wires) and increased polymer stretch ability to scale the network.
Accomplishments to Date:	Integration of 500 sensors in 4 in square initial matrix size. Matrix can be stretched 100-1000 times. Issues include damage to inter-device connections in the network during stretching.
Applications:	Hot spot monitoring, pressure bottles, fatigue crack monitoring, impact testing. Two types of architecture were discussed: 1. On board embedded system: where all components are integral to the structure. Advantageous for new platforms but not for retrofit. Wireless pros: no wiring weight, easier installation no limit to number of sensors. Cons: synchronization issues, signal interference, limited to passive sensors, power supply challenge. 2. Off board where only the sensor is on the structure nothing else. A major problem is that one cannot get continuous information. Wireless pros: no wiring weight, easier installation, no limit on number of sensors. Cons: signal interference, synchronization, both passive and active sensing challenge.
Stakeholder Involvement:	AISC EMB organization aims for role in certification and standardization of fly-by-wireless 2012 target date to introduce to end users

Other Discussion Points:	In terms of network, what is the problem? For a given structure, how does the sensor get the input and does this input relate to the state of the structure. The state of the structure can be inferred from two types of input parameters: internal (cracks, corrosion, damage, etc) and external (temperature, load intensity and position).To infer and quantify the state of the structure from external parameters only is very difficult as there mathematically no unique solution (inverse problem). Sensors can be classed into two types: passive which can only receive signal (and thus treat external parameters) and active which can also generate signal. Active sensors typically work in interrogation mode where a diagnostic wave is sent to the structure and reflected back with a signature of the internal state (damage) To develop a sensor network for a specific application, end users needs must be identified in terms of which type of parameter need to be measured and the frequency of maintenance inspections

II. RECENT DEVELOPMENTS IN SAW WIRELESS SENSOR-TAG TECHNOLOGY[3]	
Author	Jacqueline Hines
Technology Description:	Passive wireless SAW sensors tags: coding, impedance matching and range enhancement
Accomplishments to Date:	Remove ringing noise from resonances in the gratings. Techniques tried were OFC autocorrelation and cross correlation but still noisy. Better results came from using a new type of tag: Power spectrum density (PSD) of the reflected response which is inherently temperature compensated and has better separation between on and off states
Applications:	less-wire architecture SHM Inflatable habitats Test facilities
Stakeholder Involvement:	NASA (SBIR) U. Maine UCF (Don Malocha) Need: Industrial partners Need: End user Open to collaboration
Other Discussion Points:	Needs: Miniature wideband antenna, Passive energy collectors Future work: range extension

III. SURFACE ACOUSTIC WAVE PASSIVE WIRELESS MULTI-SENSOR SYSTEM[4]	
Author	Donald C. Malocha
Technology Description:	Multiple Bragg frequency devices for orthogonal frequency coding (OFC). Local carrier frequency different from device to device where frequency peak of one grating is a node of the others. Each device is thus transparent to others. Advantages: • Enormous frequency range. • Lots of coding space. • Low signal loss. • Low coding collision
Accomplishments to Date:	Good agreement between device performance and simulations Time and frequency division multiplexing. 32 code sets with good correlation First 250MHZ OFC SAW device I mm palladium device with large 60db gain 1 to 7 dB insertion loss
Applications:	NASA ground and spaceflight Harsh environments No batteries Single platform Interrogation distance of 1 -100 meters Number of sensors: 10 to 100 Focus on technologies where silicon devices cannot compete
Stakeholder Involvement:	NASA: KSC, JSC, Langley Industry: ASR&D, Mnemonics, MtronPTI, Vectron University of Puerto Rico

I. LASER ASSISTED DIRECT WRITE: A METHOD OF RFID MODIFICATION AND IN SITU SENSOR AND ANTENNA GENERATION[5]	
Author	Eamonn Fearon
Technology Description:	Laser assisted direct write is a method of manufacturing electrical components by using a laser to cure and or machine a pre-deposited pattern on a surface. The components made were printed with laser ink on different surfaces. An interesting application is the printing of integrated circuits on a flexible surface.
Accomplishments to Date:	Laser Cured particulate silver inks that has a better conductivities than manufacturers' specifications. Developed new methods of laser curing which result in desired wiring track smoothness for high frequency applications Design parts for aerospace applications.
Applications:	Since the principle advantage of the Laser Assisted Direct Write is the use of no wire, this system can be implemented where there is a need for reducing wiring weight and connectors. This system can be used to create basic electrical components like: resistors, inductors, capacitors. The integrated circuit printed on the surface can serve as a sensor to measure different changes of the surface itself. Like a damage sensor which consists of a printing on the surface that is needed to test so that the displacements of the surface is measure. To use this technology on applications more related to this workshop, industries, like the aerospace industries will have to establish their needs and requirements.
Other Discussion Points:	The present applications are performed with a single axis printer, but eventually, research will conduct to multi-axis printer. This will allow the printing of integrated circuits on curved or stepped surfaces, multiplying the possibilities of this technology.

II. POWER FOR WIRELESS SENSOR NETWORKS[6]

Authors	Ahmadreza Tabeshh and Luc G. Frechette
Technology Description:	The Wireless technology needs small, reliable and easily implementable power sources. The power consumptions of the sensor nodes are quite low but needs high peak power, therefore, the power source needs to suit that. The technology that has been developed here is the Vibration to electricity energy harvesters. This consists of making energy from the vibration caused by multiple mechanisms (Car, plane, helicopter…). The energy transformation is electrostatic, electromagnetic or piezoelectric. Piezoelectricity have been retain for his possibility to miniaturize and generate relatively high voltage and power
Accomplishments to Date:	Piezoelectric Mechanical Energy Harvesting 1-100 mW Vibrations: Piezo-ceramic bimorph beams and MEMS-based piezo resonators to power wireless sensors Strain: Bulk ceramic and fiber composites directly bonded to aircraft structure to provide electrical power for SHM applications
Applications:	Power the different wireless sensors without having to route cables from external power sources. This reduces the weight of the cabling. Other Discussion Points: The apparatus consist of a vibrating beam with layers of piezoelectric materials. The system acts like a spring-mass-damper system resonating at a vibration frequency. This vibration causes the piezoelectric to create electricity.

III. MICRO FABRICATION CAPABILITIES AND OPTICAL MICRO SENSOR ACTIVITIES AT INO[7]	
Author	Francis Picard
Technology Description:	INO is a company expert in optics and photonics. It is the largest Canadian pool of optics and photonics expertise with an industrial focus INO is specialized in the following fields: MEMS/MOEMS, optical design, specialty optical fiber, vision, sources and laser, IT communications, Energy and Environment, Industrial applications, Defense and security, Micro fabrication, technology for space and astronomy. Their role is to pass the knowledge of university and R&D to the industry.
Accomplishments to Date:	Zipping actuator, Beam Steering Mirror. Micro-mirror module : Phase Modulation with Piston-Like Micro-mirrors , Power & DSP board and MEMS driver board connected together
Applications:	Zipping actuator, Beam Steering Mirror Micro-mirror module : Phase Modulation with Piston-Like Micro-mirrors , Power & DSP board and MEMS driver board connected together Micro Bolometer, Pressure Micro-sensors., Multifunctional chip-scale optical bench, Die-level vacuum packaging, Environmental testing
Other Discussion Points:	INO is extremely interested in receiving input from the industry to orient its Internal Research Program. Coupling micro-sensors with wireless capabilities is certainly an exciting possibility.

I. GUIDED WAVES FOR STRUCTURAL HEALTH MONITORING - CHALLENGES AND OPPORTUNITIES[8]

Author	Tribikram Kundu
Technology Description:	Structural health monitoring, Non destructive inspection
Accomplishments to Date:	Elastic wave propagation modeling by DPSM (no elements only point sources)
Technology synergies:	Non isotropic material versus velocity in direction. Predict impact location without much accuracy using triangulation. Lamb wave show much clearer image and accurate
Applications:	Composite plate inspection: - putting transducer and analyzing response - Ultrasonic image C-scan images of Composite concrete interface (not telling the truth)
Other Discussion Points:	EMAT (electro magnetic transducer): Dent changed the plot of the frequency response. Defect but hard to identify which type in free pipe, but easier when it's soil embedded DPSM modeling: less leakage of energy at reflection depending of angle. Much closer to analytical case (beam reflection)

II. INTEGRATED AND FLEXIBLE ULTRASONIC TRANSDUCERS FOR HEALTH MONITORING OF AERONAUTIC STRUCTURES[9]

Author	Cheng-Kuei Jen
Technology Description:	Ultrasonic transducer
Accomplishments to Date:	Right now selling kit for paint on ultrasonic transducer and Flexible ultrasonic transducer
Applications:	Applications: Curvy structures Detection of delimitation High signal to noise ratio Provision for higher db gain Wide temperature range Thickness echo Total loss of single trough temperature raise very low. Portable Flexible: Lower temperature range Need coupling IUT may be coated bonded brazed Longitudinal shear plate acoustic waves can be generated and received NDE and structural health monitoring
Other Discussion Points:	Sustained 375 thermal cycles

III. SMART SENSORS INTEGRATION WITH A HARDWARE PLATFORM FOR AERONAUTIC STRUCTURAL HEALTH MONITORING[10]

Author	Carles Ferrer
Technology Description:	CMOS Smart sensor A component that integrate the pre-processor and the sensor that could be used with wireless if they can find a power source.
Accomplishments to Date:	Still at research level.
Technology Synergies:	Wireless communication and powering with integrated antenna CMOS Smart sensor integrate all the necessary functional blocks Power and data transfer using coils (close distance) Powering and back telemetry using coils CMOS metal only Integration of impedimentric and isfet sensor
Applications:	Integrate all component in a wireless system in a single CMOS chip
Stakeholder Involvement:	ESA, EDA, 7FPM and national funding
Other Discussion Points:	SHM Monitoring: Temps, press, humidity, stress, acceleration Flexible hardware platform Reduce size and weight Minimize power consumption Low rate data Wire vs wireless Sensor stuck on the part or structure

IV. WIRELESS SENSOR AND ACTUATION NETWORKING FOR FLY-BY-WIRELESS AVIONIC CONTROL APPLICATION[11]

Author	Anader Benyamin-Seeyar
Technology Description:	Pros and cons of going wireless and possible network solutions.
Accomplishments to Date:	Defining requirements and comparisons between network standards
Technology synergies:	Challenges: Frequencies Information integrity and performance Availability, Cost, Power, Maturity, Certification, Security Advantage: No need for wires or heavy instrument Issues: Communication Bandwidth Computational complexity Power budget Data integrity Comparison of network standards Wifi= long range high data rate Bluetooth and Zigbee low power low data rate Zigbee be more flexible Solution: developing new standard or using COTS standards (Wifim Zigbee, Bluetooth) All node goes to one central(star) or some can receive and transmit from other(mesh) Many central node and transmission between them (simplify network on the application)
Applications:	Wireless: Reduce aircraft power, mass, size Wireless sensors are typically low cost low power and small Wireless sensing technology is a key No need for wires or heavy instrument Prevent failure
Other Discussion Points:	Complexity of running wire through aircraft (also heavy) Additional problem connector shielding fastener Power loss

I. DESIGN AND CHARACTERIZATION OF AN AFDX TO CAN-AEROSPACE BRIDGE SOFT IP CORE[12]	
Author	Savaria, Guchuan Zhu, Mohamad Sawan, Normand Belanger
Technology Description:	Design and characterization of an AFDX to CAN aerospace bridge soft ip core. The goal is to implement a generic, modular and universal wireless network that can interface multiple sensor types and multiple communication protocols, using off-the shelf and certified components (COTS). Network needs to be robust and reliable with no single connections between nodes. Fault tolerant.
Accomplishments to Date:	Partial First generation design but could not implement AFDX for reasons of cost. Need to assess reliability as next step Increasing information flow within the aircraft and larger bandwidth (50000 nodes) where flight safety critical.
Stakeholder Involvement:	CRIAQ, NSERC, Resmiq, Bombardier Offers client a sizable grad student workforce for projects and many specialists in various fields (packaging, microelectronics, multiphysics, etc) Expertise exists in the field of biomedical implant devices

II. MINIATURE ULTRA WIDEBAND MODULATION SYSTEMS FOR LOW INTERFERENCE WIRELESS COMMUNICATIONS IN AEROSPACE APPLICATION[13]	
Author	M. N. El Gamal
Technology Description:	Miniaturization of sensors using MEMS technology. Some current application, but still at research level
Accomplishments to Date:	Some application already using this technology. Trying to make it fully embedded with IC
Technology synergies:	Offering fabrication. Can make lots of different sensors Need packaging to protect the MEMS
Applications:	Agriculture monitoring Sensor for aircraft engine (gas, oil leak, temps)harsh environment Hospital friendly (temps sensors on patient): low power, no interference Military equipment for covert communications Radio frequency integrated circuit: low voltage went to cell phone
Other Discussion Points:	Batch fabrication like IC for low cost and uniform device prod Many device in the same space for Redundancy and reliability, higher resolution Suitable for micro sensor It enable SiC MEMS above IC

III. WIRELESS MULTIPLE ACCESS SURFACE ACOUSTIC WAVE SENSOR[14]	
Author	Maurizio Dacunha
Technology Description:	Creating a sensor system that is wireless, passive and that have Multisensory access capabilities. The sensor system discussed here is the Surface acoustic wave (SAW) Sensor system. The implementation needs a Broadband, a Transducer and an Antenna
Accomplishments to Date:	Successful test lab with sensor transmission of several meters with non-optimized system. Creating a Surface acoustic wave sensor that resisted thermal shock. The sensor was positioned in the exhaust of a jet engine. Long term SAW sensor high temperature performance: tested up to 5 ½ month and the device were very stable.
Applications:	Microwave acoustic sensors for Harsh Environment : Physical and Chemical Hot temperature environment Stakeholder Involvement: ENVIRONETIX TECHNOLOGIES

REFERENCES

1. CANEUS Fly-By-Wireless 2009 Handbook pp.36-42

2. Fu-Ko Chang , Implementation for Structural Health Monitoring, FBW09 Presentations. http://caneus.org/fbw/content.aspx?id=resources_2009

3. Jacqueline Hines, Recent developments in SAW wireless sensor-tag technology, FBW09 Presentations. http://caneus.org/fbw/content.aspx?id=resources_2009

4. Donald C. Malocha, Surface acoustic Wave Passive Wireless Multi-Sensor System, FBW09 Presentations. http://caneus.org/fbw/content.aspx?id=resources_2009

5. Eamonn Fearon, Laser Assisted Direct Write: A Method of RFID Modification And In Situ Sensor And Antenna Generation, FBW09 Presentations. http://caneus.org/fbw/content.aspx?id=resources_2009

6. Ahmadreza Tabeshh and Luc G. Frechette, Power for Wireless Sensor Networks, FBW09 Presentations. http://caneus.org/fbw/content.aspx?id=resources_2009

7. Francis Picard, Micro fabrication capabilities and optical micro sensor activities at INO, FBW09 Presentations. http://caneus.org/fbw/content.aspx?id=resources_2009

8. Tribikram Kundu , Guided Waves for Structural Health Monitoring- Challenges and Opportunities, FBW09 Presentations. http://caneus.org/fbw/content.aspx?id=resources_2009

9. Cheng-Kuei Jen , Integrated and Flexible Ultrasonic Transducers for Health Monitoring of Aeronautic Structures, FBW09 Presentations. http://caneus.org/fbw/content.aspx?id=resources_2009

10. Carles Ferrer , Smart Sensors Integration with a Hardware Platform for Aeronautic Structural Health Monitoring, FBW09 Presentations. http://caneus.org/fbw/content.aspx?id=resources_2009

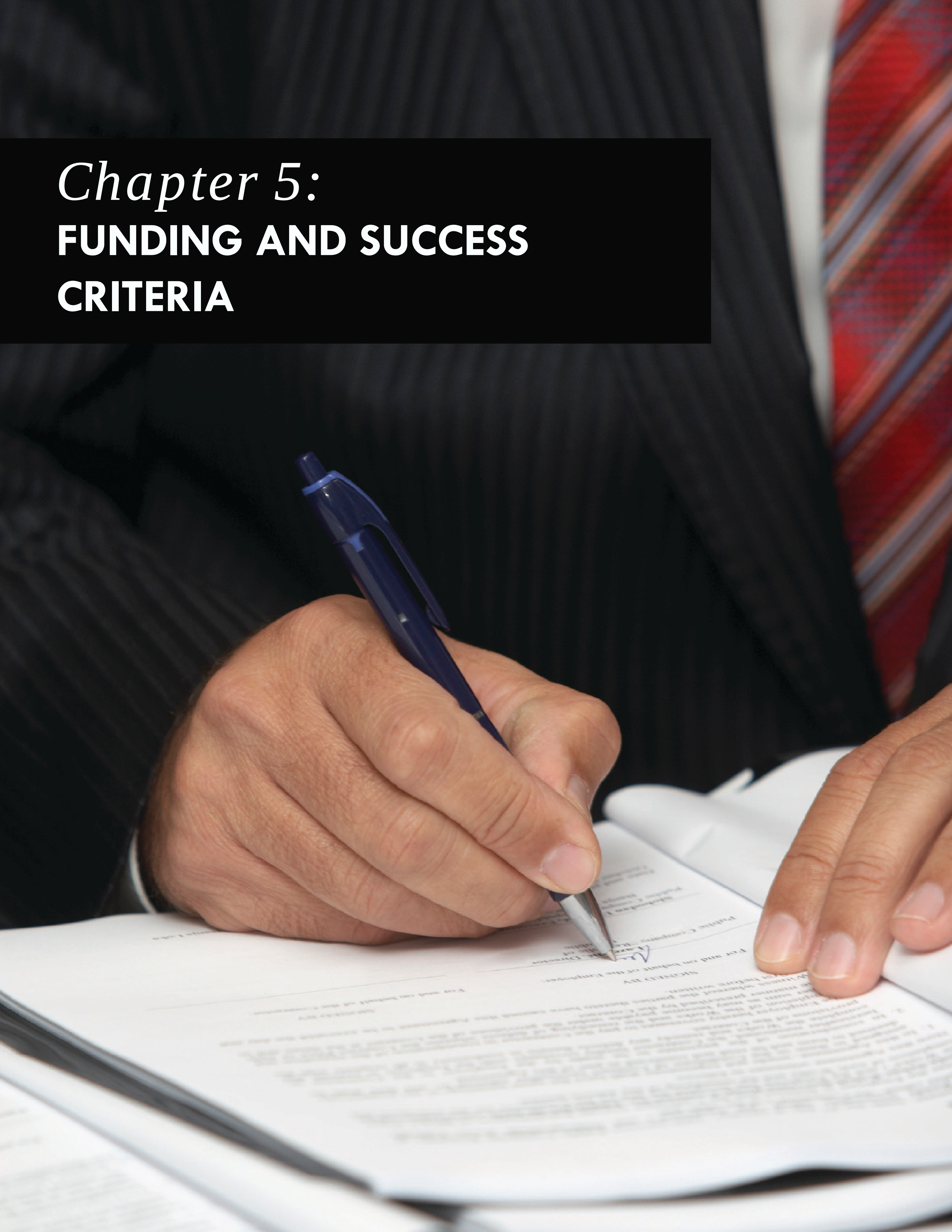
11. Anader Benyamin-Seeyar , Wireless Sensor and Actuation Networking for Fly-By-Wireless Avionic Control Application, FBW09 Presentations. http://caneus.org/fbw/content.aspx?id=resources_2009

12. Yvon Savaria, Guchuan Zhu, Mohamad Sawan, Normand Belanger, Design and Characterization of an AFDX to CAN-Aerospace Bridge Soft IP Core, FBW09 Presentations. http://caneus.org/fbw/content.aspx?id=resources_2009

13. M.N. El Gamal, Miniature Ultra Wideband Modulation Systems for low Interference Wireless Communications in Aerospace Application, FBW09 Presentations. http://caneus.org/fbw/content.aspx?id=resources_2009

14. Maurizio Dacunha , Wireless Multiple Access Surface Acoustic Wave Sensor, FBW09 Presentations http://caneus.org/fbw/content.aspx?id=resources_2009

Chapter 5: FUNDING AND SUCCESS CRITERIA



CHAIR AND CO-CHAIRS

- Carlos Trindade, CRIAQ (Consortium for Research and Innovation in aerospace in Quebec)
- Rick Earles, CANEUS USA
- Peter Eggleton, Telligence Group
- Anader Benyamin-Seeyar, IEEE Montreal
- Suzanna Benoit, CEO-AERO Montreal

SPEAKERS

- David Russel, Flight Research Laboratory, Institute of Aerospace Research, National Research Council Canada
- Maurizio Dacunha, University of Maine
- Brian McCabe, Sikorsky Aircraft
- Fidele Moupfouma, Bombardier Aerospace Core Engineering, Montreal
- Gabriella Graff-Innes, CCC (Canadian Commercial Corporation)
- Denis Godin, NSERC (Natural Sciences and Engineering Research Council), Canada
- Carlos Trindade, CRIAQ (Consortium for Research and Innovation in aerospace in Quebec)
- Yves Plourde, IRAP (Industrial Research Assistance Program), Canada
- Jim Brockbank, VP Transportation, Export Development Corporation
- Linda Beth Schilling, NIST (National Institute of Standards and Technology) - Technology Innovation Program
- Frank Barros, NIST (National Institute of Standards and Technology) - Small Business Innovation Research
- Adarsh Deepak, CEO Science and Technology Corp.
- Roy Vestrum, Flight Research Laboratory, Institute of Aerospace Research, National Research Council Canada
- Todd Farrar, Business Acceleration Manager, Dawnbreaker Inc.

OVERVIEW[1]

Topics covered in the sessions from the second part of the workshop fed into the third part of the workshop on funding and project success criteria wherein participants applied the knowledge acquired during the previous sessions towards formulating and implementing existing, as well as new projects. Finally, as a measure of the workshop success, each project team presented the findings and outcome to gauge project completion and milestone achievements, and the avenues to be pursued to overcome challenges such as intellectual property, funding, and government regulations (such as ITAR).

The 'project overview' sessions aimed to refine the well-defined projects, both existing reviewed as well as new pro-posed: participants outlined teaming and funding schemes, planned project oversight and execution, and established milestones from which to gauge success of the project. The funding session addressed the priorities of government programs in developing and funding such programs, as well as potential projects, leading to procurement actions.

Finally, the 'project success criteria' session addressed the selection criteria, metrics used for assessing progress, program duration, and strategies for infusing these technologies into aerospace applications. In this session, participants delved further into focused activities to include tasks, responsibilities, timelines, teaming, budget, and success evaluation metrics.

CANEUS FUNDING MECHANISM[2]

Funding provides the means for initiating, maturing and implementing new systems. This session addressed the priorities of government programs in developing and funding such programs, as well as potential projects, leading to procurement actions.

The goal of CANEUS International is to support the definition and execution of MNT projects important to the consortia project team members.

Therefore, CANEUS needs to ensure that requisite funds are in place in order to support the administration and definition process, and the work program of each project.
The CANEUS funding mechanism consist of: (a) consortium membership dues to cover the cost of administration and project definition phases, and (b) funding obtained through in-house funds from agencies and/or those institutions or by taking advantage of open solicitations for the project.

All funding decisions are strongly influenced to maximize the return on investment (ROI) for the consortium members. It is the responsibility of CANEUS organization to develop the most compelling Project proposals that respond directly to the needs of the Aerospace community.

Sponsored Programs

CANEUS will actively campaign with various aerospace agencies and institutions to establish funding for a program with a MNT scope that is critically important to those agencies or institutions. The funds would be doled out by CANEUS to support projects that are responsive to the define program scope.

Solicited Project Funds

CANEUS will take compelling Project Concept Proposals and facilitate the Project Proposal Campaign to acquire funding from open competitive solicitations such as broad agency announcement or call for proposals for example.

Unsolicited Project Funds

CANEUS will take compelling Project Concept Proposals and facilitate the Project Proposal Campaign to acquire funding from agencies or institutions through direct inquiries with Program managers from those agencies or institutions that have areas of interest that require solutions which CANEUS is able to provide.

Member Match

Whatever the total cost required is to complete the development and commercialization of a project or service, CANEUS will extract funds from all the applicable/interested sources. If a particular source requires in-kind match to qualify for the funds, CANEUS will coordinate the project team member's resource contribution

Income from Operations

Funds that come into CANEUS from revenue generating services (for example an international MNT resource web portal), will be made available (minus any program costs) for development projects.

PROJECT FUNDING AND ISSUES

I. University- 'Research Partnerships Programs' (NSERC)

The 'Research Partnerships Programs' session discussed several issues regarding funding including the evaluation criteria for acquiring funding, the reasons for failure to acquire grants, as well as regulatory compliance issues.

The objective of "strategic project grants' is essentially to increase research and training in targeted areas that could strongly influence Canada's economy, society and/or environment within the next 10 years. The following are key points on funding issues in the University research sector:

Evaluation Criteria
When evaluating a research grant proposal, some of the criteria that are kept under consideration are the research project quality and originality, the expertise of the research team, the training of highly qualified personnel, industrial relevance, private sector support, and potential benefits to Canada. It was noted that this last criterion refers to Canadian-based companies that can apply the research results in a way that generate wealth or employment (organizations without Canadian R&D or manufacturing operations will not be considered).

Reasons for failure
Some common reasons for which some research grants are not awarded were noted as following: questionable scientific merit: poor originality, technical problems, not research; poorly situated within state of the art; a lack of details in proposed methodology; a schedule wherein the scope is too

ambitious, budget items are poorly justified, and perhaps too high; a lack of team expertise; and finally in-kind not being essential to the project, over estimated, and poorly described.

II. Commercial (CCC)

The session that dealt with funding through a commercial contractor such as the CCC (Canadian Commercial Corporation) focused primarily on the benefits of seeking funding through the commercial avenue as well as the process involved.

Benefits

By contracting through a commercial corporation, benefits include: minimized risks, evaluation and certification of suppliers, simplification of the procurement process (Government – to – government process, advice in contracting internationally, facilitates financing access) and efficiency. Moreover, the Corporation would be responsible for certification of technical, financial and managerial capability of the Canadian supplier, the fair and reasonable pricing endorsement for DoD and NASA as per DFARs, and so on. More specifically on the funding front, a commercial corporation would primarily assist in identifying sources of financing and administration of funds.

III. Risk Management Agencies (EDC)

Another possible avenue for project funding that was discussed during this session was the use of a risk management agency such as the EDC (Export Development Canada). A risk manager like the EDC provides certain benefits with regards to financing such as: bank guarantees, buyer loans, lines of credit, Canadian Direct Investment Abroad (CDIA), Note Purchase Agreements, and an equity program.
Risk management services include: accounts receivable insurance, Political Risk Insurance, and contract bonding. With regards to an organization like CANEUS, an agency such as this would potentially support CANEUS projects at the point of manufacturing and commercialization.

IV. Prototype Demonstration- Strategic Aerospace and Defence Initiative and STDC

Program's Objective

The Strategic Aerospace and Defence Initiative (SADI) was created to support Canada's aerospace and defence (A&D) industries. Support is provided through repayable financial contributions to Canadian companies as they undertake research and development (R&D) projects in the aerospace, defence, space and security sectors. The initiative is administered by the Industrial Technologies Office (ITO), a special operating agency of Industry Canada.

Funding Process

Every research and development project being considered for SADI funding is subject to an eligibility test and a thorough and multi-phased process of technology and business assessment and due diligence. The objective of the assessment and due diligence phases is to ensure that a strong business case exists for each project and that the applicants demonstrate the managerial, financial, business planning and technological expertise to successfully complete the project. Projects that meet the eligibility requirements and successfully complete the due diligence process are then subject to a multi-level approval process within Industry Canada. Should the project receive final approval by the Minister, Treasury Board and/or Cabinet, funding is provided under the terms of an agreement that defines the mutual obligations of the successful applicant and the Crown.

ITO employs rigorous due diligence and strong internal controls as a way to ensure that funds are invested wisely on behalf of Canadians.

For more information on "Proposal Preparation Guide," visit www.ito.ic.gc.ca ,

Sustainable Development Technology Canada (SDTC)[4]

Sustainable Development Technology Canada (SDTC) is a not-for-profit foundation that finances and supports the development and demonstration of clean technologies which provide solutions to issues of climate change, clean air, wa-

ter quality and soil, and which deliver economic, environmental and health benefits to Canadians.
SDTC operates two funds aimed at the development and demonstration of innovative technological solutions. The $550 million SD Tech Fund™ supports projects that address climate change, air quality, clean water, and clean soil. The $500 million NextGen Biofuels Fund™ supports the establishment of first-of-kind large demonstration-scale facilities for the production of next-generation renewable fuels.

Mission and Mandate

SDTC was established by the Government of Canada in 2001 and commenced operation in November of that year. SDTC's mission is to act as the primary catalyst in building a sustainable development technology infrastructure in Canada. The Foundation reports to Parliament through the Minister of Natural Resources Canada. We do much more than simply fund groundbreaking technologies. We work closely with an ever-growing network of stakeholders and partners to build the capacity of Canadian clean-technology entrepreneurs, helping them form strategic relationships, formalize their business plans, and build a critical mass of sustainable development capability in Canada.

PROJECT DEVELOPMENT AND SUCCESS CRITERIA[5]

i.Overview

The project development portion of the workshop is when attendees, empowered with a clear understanding of end-user needs from day one and the development activities of various technology providers from day 2, come together to create project concepts that can provide a real solution that addresses discrete end-user needs. These sessions aimed to refine the well-defined projects; both existing reviewed as well as new proposed. During the sessions, participants outlined teaming and funding schemes, planned project oversight and execution, and established milestones from which to gauge success of the project.

Based on the understanding of what solutions were desired by end-users/customers (outlined on Day 1) and the maturity of currently developing technologies (outlined on Day 2), participants applied the knowledge acquired during the prior sessions towards formulating and implementing existing as well as new projects. Teams on day three therefore worked towards developing project frameworks by leveraging the involvement of consortium members including technology providers, end-users, customers, integrators, and other value chain members.

ii.Goals

The overarching goal for these sessions was to create project concepts that could provide a solution to end-user and customer needs. The goal post-workshop was to refine the project concepts, establish a complete project plan or proposal, and to secure funding for the projects.

iii.CANEUS Project Definition and Implementation Process

CANEUS uses a 2 step approach to define projects. The process is divided into a Project Concept Proposal step and a Detailed Project Plan step. The first step of the process results in a Quad chart and an associated supporting document (see appendix C and D) that represents a high level description of the project. The first step is intentionally made simple so that an inordinate amount of resources is not expended by your organization on a project concept proposal that may not appeal to a broad base of members. The Quad chart along with associated documents is submitted to the CANEUS Project Review Committee for their approval. Once the go ahead is given, the project team may progress to step 2 – the Detail Project Plan phase. The completion of the Quad chart and supporting documents is the phase of the definition and implementation process we are striving to achieve at this workshop.

A Detailed Project Plan is an extension of the Project Concept proposal but with much greater detail that includes proprietary content especially as relates to unique technology development, work breakdown, costs, specific IP terms and the business model. The step also includes the preparation and execution of a teaming agreement that is specific to the project and legally binds the team members to the project plan.

Once a Quad chart is submitted, the CANEUS organization becomes actively involved in "shepherding" the project through its various life-cycle phases with the close involvement of both the potential financial sponsors and the end-customers. CANEUS strongly believes that such an intimate collaboration between all the stake-holders is necessary right from the inception of the project in order to ensure the ultimate success in transitioning MNT concepts to the aerospace system level.

iv.Critical Success Factors

In the CANEUS Innovation Model, it is recognized that Projects are more successful and effective at mitigating risk and cost when they contain or address certain critical success factor. CANEUS Projects are high risk – high cost and typically of a larger scope and thus tend to have a greater number of challenges to address throughout the continuum of the devel-opment and commercialization process. Most of the Aerospace community measures this process using a system of "technology readiness levels" (TRLs), of which there are 9. The middle TRLs (typically TRL 3 to TRL 5) are sometimes referred to as the "valley of death" and have proven to represent the greatest challenge of all. To mitigate the risk and cost associated with this process and to ensure all the TRLs are handled expeditiously, the CANEUS Innovation and commercialization model uses a "recipe for success" that lays out the critical constituents that should be included in every CANEUS Type 1 – Development Project.

v. Lessons Learned

- ***Pre-Workshop Project Identification***
  The lesson learned is that it is important to indentify project ideas before the workshop starts. This would help to ensure that the project ideas representing the best opportunities for the attendees are used. This would also allow more time to be spent during day 1, day 2 as well as day 3 on project concept creation.
- ***Joint End-User and Tech-Provider Attendance- Critical to Successful Project Creation***
  To successfully create a project concept during a breakout session it is critical to have the key stakeholder groups represented including end-users, customers, technology providers, and other value chain members. Capturing or documenting end-user needs is not enough to allow technology providers or other stakeholder to develop a complete project concept during a breakout session. It is critical that the end-users and technology providers are both present during the project concept creation. This allows for better brainstorming, unforeseen or unaddressed questions to be answered, and a project concept to be created that can best utilize the technologies represented by the group to provide a solution to the needs expressed by the end-users/customers.

CONCLUSION

Overall, considering the challenges faced, four project concepts were established as a result of the efforts that took place during the FBW 2009 workshop. These project concepts need further refinement and clarification which would include project work plan or roadmap creation. Funding will need to be secured in the near term to help with this. In addition, because project team members are university researchers, SME, etc. they lack the time and resources to refine the project concepts and to create a larger project plan on their own. Therefore it was recommended that CANEUS provides project management support to each of the project teams. This may include a dedicated project manager who manages and coordinates the activities of each project team and oversees the creation of a project work plan.

REFERENCES

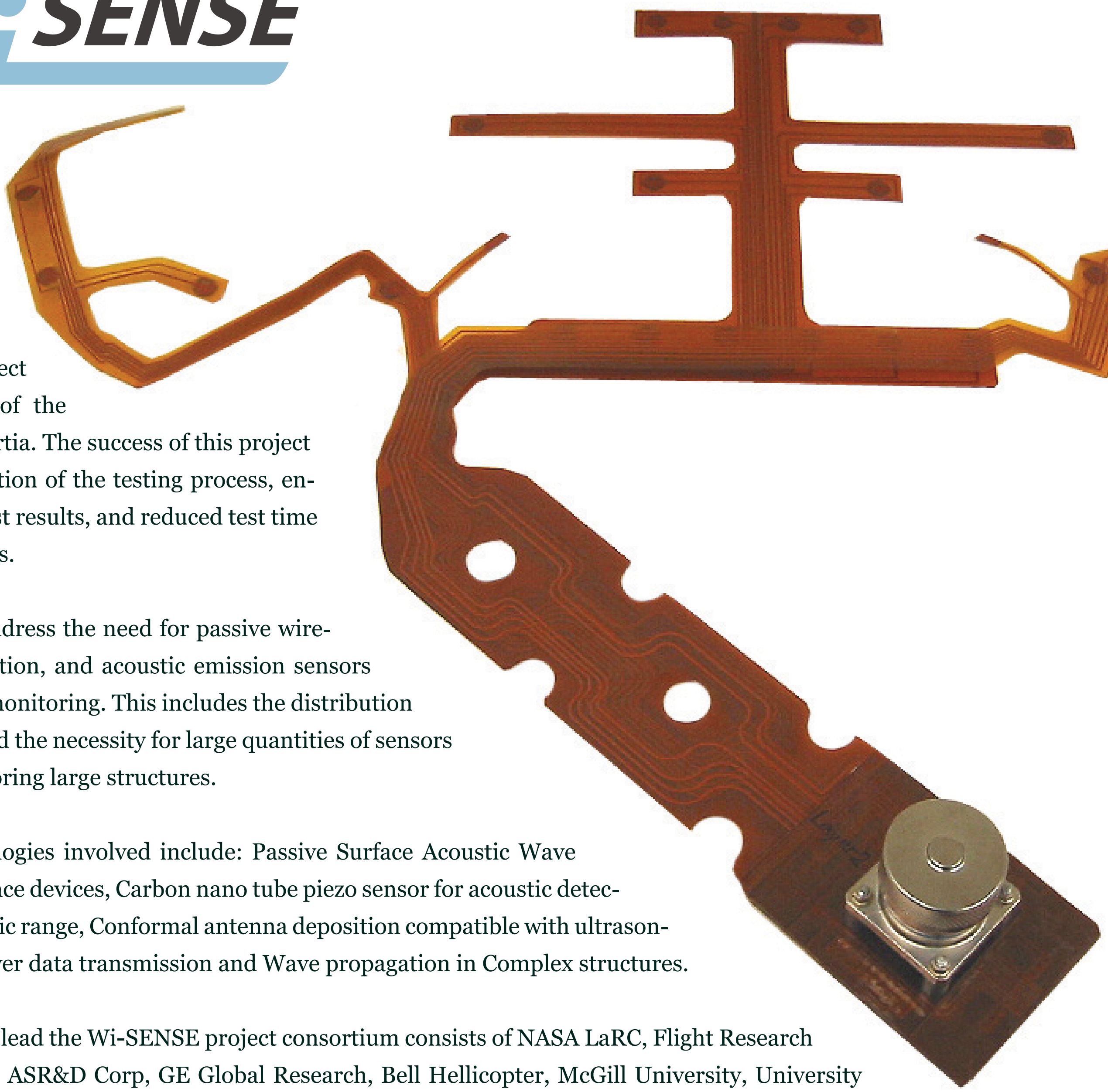
1. CANEUS FBW09 Workshop Handbook pp.10-11
2. CANEUS FBW09 Workshop Handbook p.47
3. Denis Godin, Gabriella Graffe-Innes, Jim Brockbank, "FBW09 Presentations", http://caneus.org/fbw/content.aspx?id=resources_2009
4. "SADI" http://ito.ic.gc.ca/eic/site/ito-oti.nsf/eng/h_00022.html and "Sustainable Development Technology Canada " http://www.sdtc.ca
5. CANEUS FBW09 Workshop Handbook pp. 28-34

Chapter 6: FBW CONSORTIUM PROJECTS

INTRODUCTION

The CANEUS FBW09 Workshop took a practical approach in order to efficiently overcome the challenges associated with matching aerospace application needs with the new capabilities offered by emerging fly-by-wireless technologies. Therefore the workshop activities focused on producing a set of measurable deliverables with lasting impact for the aerospace industry. After addressing the current and future needs of the end-users in the aerospace industry, workshop participants prepared a set of four projects with significant mutual benefits and high funding potential that seek to address those needs.

WI SENSE



Wireless passive acoustic emission sensors for structural and spacecraft health monitoring will be developed by the Wi-SENSE Project Consortium as part of the CANEUS FBW Consortia. The success of this project will lead to simplification of the testing process, enhanced accuracy of test results, and reduced test time for larger surface areas.

Wi-SENSE aims to address the need for passive wireless thermal, acceleration, and acoustic emission sensors for structural health monitoring. This includes the distribution of sensor networks and the necessity for large quantities of sensors for testing and monitoring large structures.

The proposed technologies involved include: Passive Surface Acoustic Wave (SAW) wireless interface devices, Carbon nano tube piezo sensor for acoustic detection up to the ultrasonic range, Conformal antenna deposition compatible with ultrasonic frequency, Low power data transmission and Wave propagation in Complex structures.

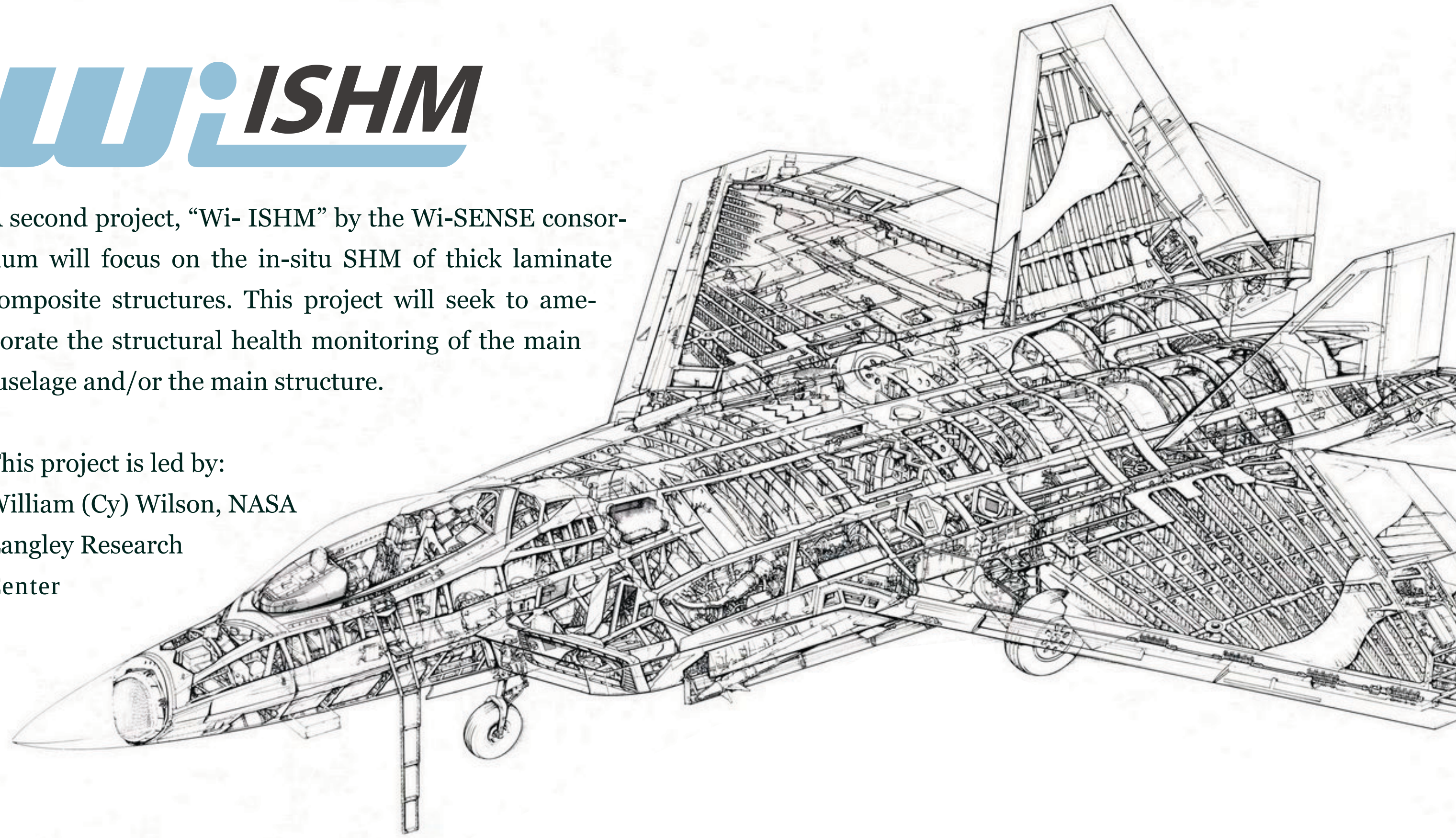
The proposed team to lead the Wi-SENSE project consortium consists of NASA LaRC, Flight Research Laboratory IAR-NRC, ASR&D Corp, GE Global Research, Bell Hellicopter, McGill University, University of Liverpool, CNM-Spain, University of Sherbrooke and University of Arizona. Other stakeholders will include potential customers such as ESA, Boeing and EADS; integrators and solution providers from the Americas, Europe, Brazil and Japan.

This project is led by: David Russel, Group Leader, Electronics and Flight Instrumentation, Institute for Aerospace Research, National Research Council Canada

Wi-ISHM

A second project, “Wi- ISHM” by the Wi-SENSE consortium will focus on the in-situ SHM of thick laminate composite structures. This project will seek to ameliorate the structural health monitoring of the main fuselage and/or the main structure.

This project is led by:
William (Cy) Wilson, NASA
Langley Research
Center



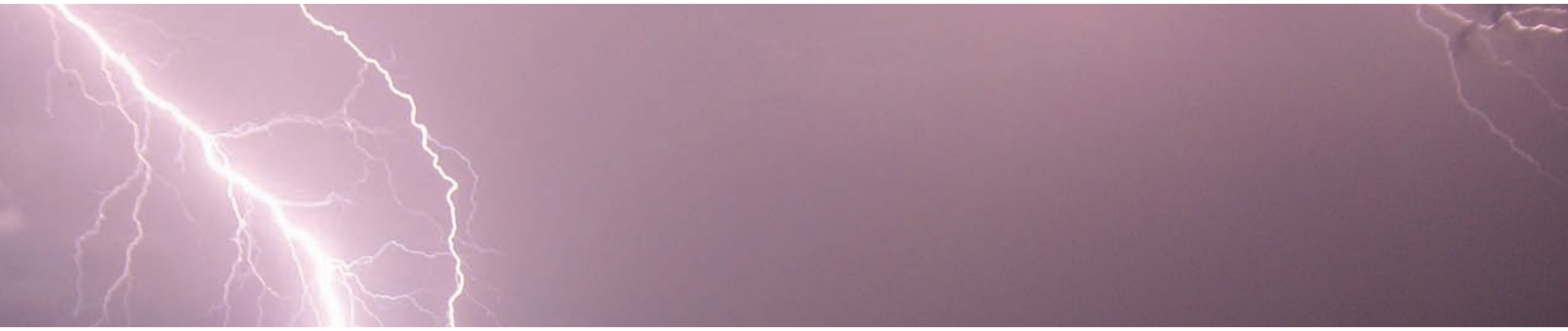
Wi-TESTBED

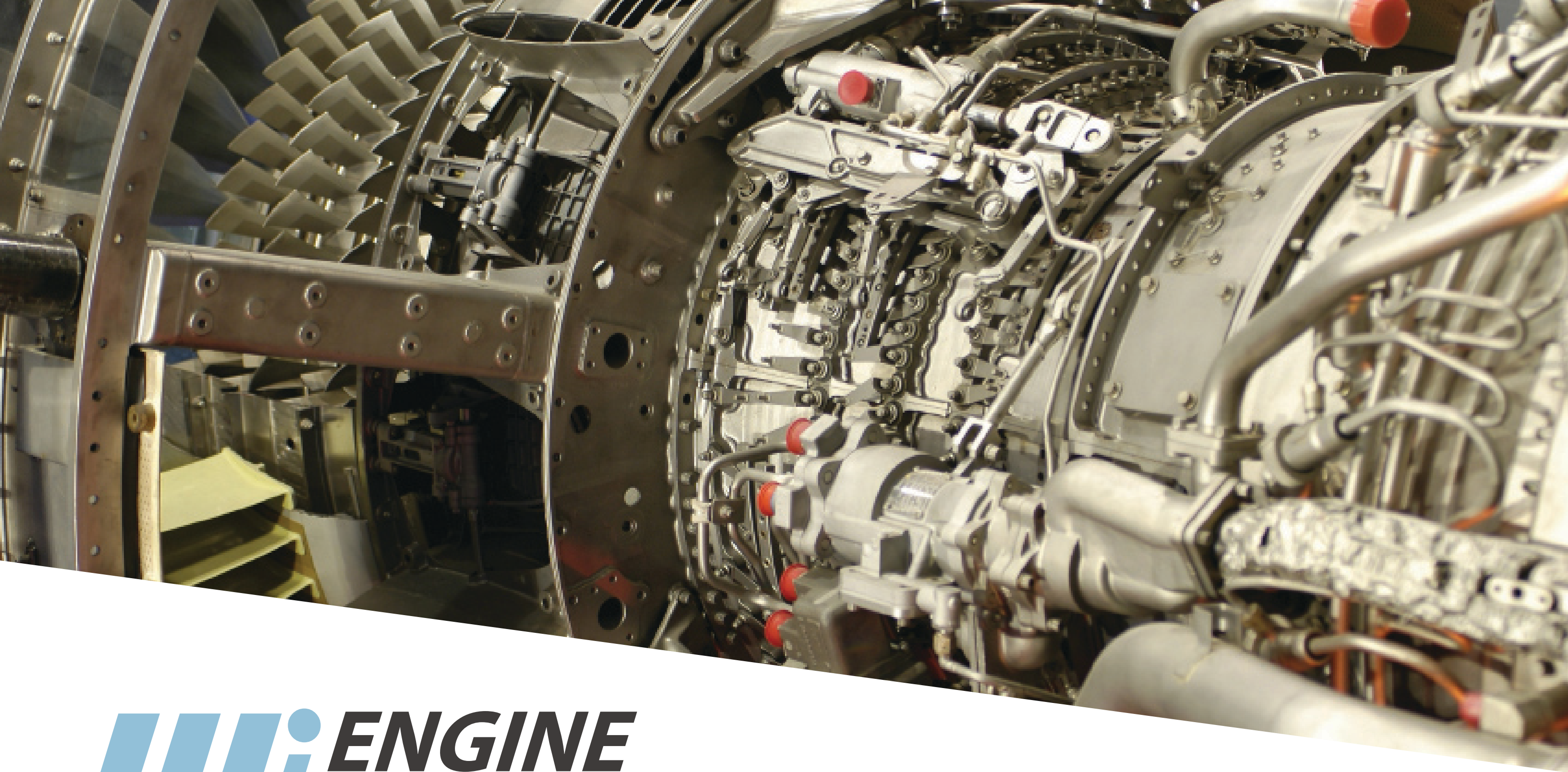
Wireless testbeds to evaluate protocols for critical communications with airborne applications, will be developed by the Wi-TESTBED Project Consortium as part of the CANEUS FBW Consortia.

Wi-TESTBED aims to implement a wireless testbed to evaluate the most appropriate protocol for critical communications with airborne applications; ID key performance nodes, and Resistance to EMI/EMP/HIRF.

Wi-TESTBED project will address the testing needs such as the robustness of systems (ie. hacking, security); interference between planes (equipment, personal devices); environmental (external, high altitude reliability); performance, power, protection of critical nodes; static and dynamic testing; and certification testing (encryption, etc). The proposed team to lead the Wi-TESTBED project consortium consists of Ridgetop Group, Bombardier Aerospace, Hydro Quebec, FRL – NRC, École Polytechnique de Montreal, University of Toronto, York University and solution providers.

This project is led by: Douglas Goodman, CEO, Ridgetop Group Inc.





WiENGINE

Wireless Sensor System for Engine Monitoring will be developed by the Wi-ENGINE Project Consortium as part of the CANEUS FBW Consortia.

The aim of the Wi-ENGINE project is to replace the wiring harness and sensors currently used for engine monitoring with a wireless system that reduces the wire, wire connectors, wire holds, weight, component volume, system cost and maintenance cost. Through the implementation of a wireless system, the reliability and manufacturability will also be improved.

The project will deal with ground testing of turbine engines, engine temperature, pressure sensing, flow, speed and active inlet. The proposed team to lead the Wi-ENGINE project consortium consists of McGill, NASA LaRC, Pratt & Whitney Canada, LMCO Skunkworks, University of Central Florida, ASR&D Corp., University of Maine, University of Sherbrooke, and MEMS Vision Inc.

This project is lead by:
Mourad El-Gamal, McGill University & Founder, MEMS Vision Inc., Montreal

Wireless Sensor Systems for Engine Monitoring

PROJECT DESCRIPTION

Objective/Problem Statement: Replace the wiring harness and sensors currently used for the PW 200 series engine monitoring with a wireless system that reduces the wire, wire connectors, wire holds, weight, component volume, system cost and maintenance cost. Through the implementation of a wireless system, the reliability and manufacturability also will be improved.

Approach: Develop a wireless nano/MEMS based suite of sensors for a turbine engine. Additionally, develop a wireless sensor interface daughter board and associated software for the FADEC and control modules. The effort will include the design, development, qualification, manufacture, and product release of a complete system solution. Develop commercially viable speed pick-up, oil pressure sensor, fuel pressure sensor, chip detector sensor, and turbine temperature sensor capable of replacing the existing sensors (the same form, fit, and function). We will use a combination of active, passive, and scavenging concepts for the sensors. Also, need to develop the high speed interface to the sensors and integrate the developed hardware into the system controller elements. Cost target/sell price for system is $9,000 (cost of current harness) plus $1,000 for each sensor.

Challenges: Size, temperature range, cost, robustness, durability, EMC, packaging, wireless range, frequency spectrum, manufacturability, establishing a supply chain

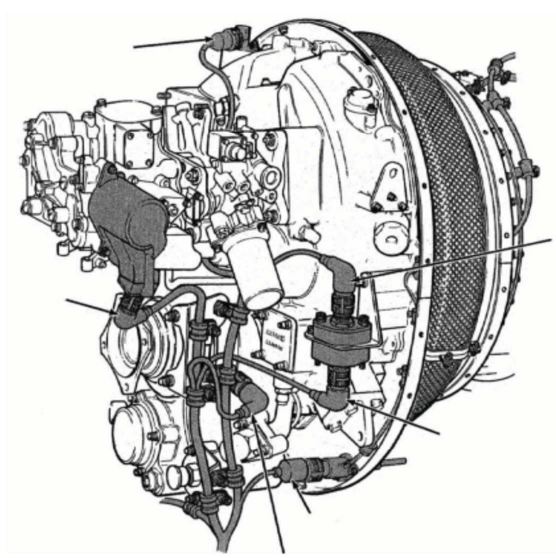
Applications: Turbine engine monitoring systems – aero and industrial, IC engine monitoring systems, industrial burner monitoring systems, harsh environments.

BACKGROUND

The PW200 series engine is a highly desirable platform for a demonstration type project due to its popularity (used on many helicopters and UAVs) and since all electronic systems are backed up by mechanical systems – loss of sensor data will not cause catastrophic failure. Once the wireless implementation is demonstrated on the PW200 series engine, the developments will be appropriate for most other non-critical functions on other turbine engines. This project effort will also lay the foundation for the supersonic active engine inlet project that is currently in the definition stage.

State-of-the-art: SAW type wireless devices exist for each of the sensor functions (including high temperature). Sensors require commercially viable packaging/miniaturization, and environmental compatibility. Both passive and active wireless concepts exist but currently do not fit within the form, fit and function of the existing sensors.

Scope: Define detailed sensor and system requirements, develop sensors (coded wireless with scavenging if required), develop sensor interfaces, test/evaluate/qualify system components, long-term test in vehicle, establish manufacturing capabilities, establish supply chains, etc.



Deliverable: Wireless temperature (both high and moderate) sensor, speed sensor, pressure sensor, torque sensor, and chip detect sensor. Interface board and software for FADEC, Fuel Management Module and gearbox monitor module.

Relevance: This project is an ideal demonstration of the great potential for a wireless system to save cost, weight, volume, and improve reliability. This project will also provide the foundation for many of the other FBW projects including the Active Inlet program.

PROJECT EXECUTION

Project Team: Pratt & Whitney (Canada), Lockheed Martin, McGill U., CLS3, U. of Maine, U. of Central Florida, U. of Sherbrooke, MEMS-Vision Inc. System solution providers and suppliers to be named later on.

A system solution provider (Honeywell has expressed interest) and commercial suppliers will be identified and added to the team before the project concept proposal is completed – the names will be added as soon as the existing team is identified and engages the appropriate candidates. The technology provider team members offer collectively a portfolio of technologies that can be used separately or combined towards the developments sought here. In summary, Sherbrooke University has expertise in energy harvesting and capacitive-based sensors for harsh environments, CLS3, McGill Univ. and MEMS-Vision Inc. have expertise in SiC-based MEMS devices and wireless integrated circuits and interfaces, and the Univ. of Maine and Univ. of Central Florida have expertise in SAW-based sensors for harsh environments.

POC:
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ROM Cost:

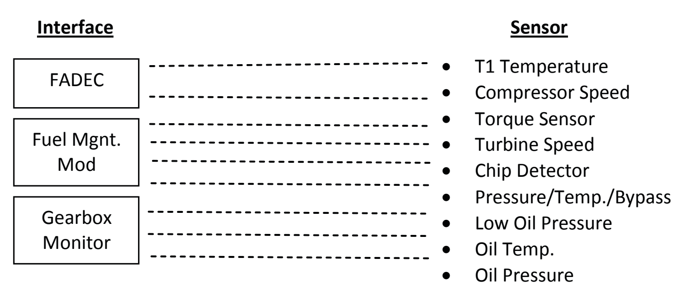
Fiscal year	01	02	03	04
ROM Project Cost ($K)	1,500	3,000	1,500	
Potential In-kind match($K)	750	1,500	750	

Potential Funding Sources: CSA, NASA, Air Force, ESA, NRC

CRITICAL SUCCESS FACTORS

Outreach: The team will coordinate its activities with other organizations pursuing wireless and sensor systems development harsh environment sensors, high temperature electronics, and SAW type devices such as NASA, ESA, US DoD, PNNL/DoE, Honywell, TriQuint and US Air Force. Less industrial activities exist for the SiC technology. Related activities on sensors for harsh environments are pursued in the car engines industry, e.g. by companies such as Nissan. Both Case Western and UC Berkeley universities may also have complimentary SiC-based knowhow and technologies.

PW 200 Series Engine



Technology: Other complementary technologies needed in addition to the portfolio of sensors to be developed include 1) high temperature integrated electronics, 2) miniature, low power monitoring and control systems, 3) data reduction software, 4) integrated wireless data transmission devices, 5) harsh environment packaging. In addition, the technologies developed here can be beneficial to the CANEUS "Small Satellites and Devices" Consortium, and we can benefit from the knowhow and technologies of the CANEUS "Materials and Reliability" Consortium.

Applications: Some of the sensors, electronics, software, and data transmission devices to be developed here can be beneficial to other applications within and outside the Aerospace industry. In addition to the small turbine engine application of this project, both aero and industrial turbines, automotive engine, marine engine, transportation engine and industrial burners all have afford an opportunity for the wireless sensing of non-critical functions.

Stake Holders: The direct customers/end users for the project are represented by Pratt and Whitney (Canada) and Lockheed Martin. The academic and agency based team members will support the technology development role. A commercial market lead/solution provider is currently being recruited for the team. Other team members that fill out the supply chain for example material suppliers, micro fabricators, and packaging service providers for will be added to the team. All of these supply chain partners will be recruited and become involved, as soon as the system requirements are defined and technology gaps are identified.

Business Development: The team will focus on the turboshaft engine opportunity associated with rotor aircraft and UAVs. With the team comprising a supply chain, the solution provider/systems integrator will have responsibility for maintaining a viable business case for the project. Based on market data from Forecast International and assuming the Pratt and Whitney engine is the first application of the team's development efforts, an estimate of income for the potential business determined. Also, Rolls Royce (they have a turboshaft engine that plays in the same market) content is added to the income stream starting in the third year of the income schedule. Assuming the unit price for a wireless engine monitoring system is $18,000 and the COGS as a percent of sales starts at 70% and decrease to 50% in three years, the following table illustrates the potential business performance. An assumption was made that none of the commercial engine programs would be affected until 2012.

Income Profile	FY01	FY02	FY03	FY04
Potential Product Sales ($M)	6.75	6.66	10.08	9.85
Target Cost of Goods Sold ($M)	4.72	4.7	7.1	5

Regulatory Compliance: A major regulatory issue that needs to be addressed early on in this project is related to the wireless communications protocols, frequency bands, modulation schemes, etc., that are allowed in different countries. The FCC, CSE and EC regulations for wireless devices will be adhered to throughout the requirements and product validation phases of this project.

Education: Three universities are already involved in this project (list above). Important skills need to be created in the area of simulation, data reduction/networks, micro fabrication, packaging and fixturing of micro /SAW sensors and electronics for harsh and high temperature environments. Each of the Universities has unique facilities which will be used throughout the development project.

Wireless Evaluation Testbed

PROJECT DESCRIPTION

Objective/Problem Statement: There is a need to characterize the operation and behaviour of wireless systems when used in an aerospace environment. Variables include the selected transmission methods, frequencies employed, protocols, and vulnerability to detrimental environmental effects (radiation, EMI, EMP, HIRF etc) or deliberate attempts to disrupt proper operation by passengers or other sources.

Approach: Develop a wireless test bed that can used to evaluate the efficacy of wireless communication of data within an aircraft platform. This will include the development of modular transmitter and receiver assemblies, control software, example application(s), such as CPU control of an electromechanical actuator using wireless communication to show functionality.

Challenges: Representative environmental test conditions, fabrication of test bed, prioritization and selection of wireless protocols, cost, ability to meet FIT objectives.

Applications: Aircraft diagnostic and prognostic monitoring systems, entertainment systems, limited actuator controls.

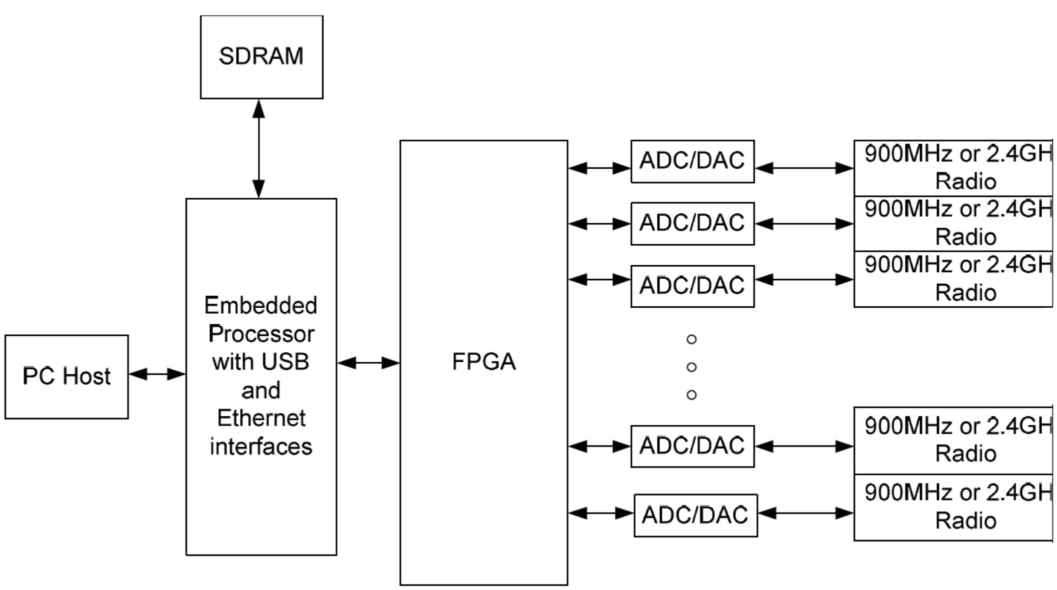
BACKGROUND

State-of-the-art: Wireless transmission of data has been widely adopted for use with laptop computers and handheld wireless devices. The application of wireless technologies to more critical applications, such as FBW offers the potential to greatly reduce the weight of cabling in aircraft.

Scope: There is a need to evaluate several wireless standards, new emerging protocols and transmission frequencies on a standardized test bed. This test bed will permit objective measurements of the performance of the wireless transmissions in a controlled setting where worst-case environmental conditions can be applied. The results of this testing will yield the most robust wireless method for use in aircraft.

Deliverable: Test bed for testing of various wireless standards for aerospace applications, test results of different standards, and test results.

Relevance: The project and test results are critical to the successful deployment of wireless transmission for aerospace fly-by-wireless applications.



PROJECT EXECUTION

Project Team: Bombardier, Ridgetop, University of Toronto, NRC, York University, Ecole Polytechnique, Concordia. Others to be added later.

ROM Cost:

Fiscal year	01	02	03	04
ROM Project Cost ($K)	500	1,500	1,500	
Potential In-kind match($K)	250	750	750	

Potential Funding Sources: CSA, FAA, NASA, Air Force, NRC, NAVAIR, Boeing, Lockheed, Honeywell

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Passive SAW sensors based Smart Wireless System

PROJECT DESCRIPTION

Objective/Problem Statement: To address the need for wireless passive acoustic emission sensors for structural and spacecraft health monitoring which leads to the simplification of the testing process, enhanced accuracy of test results and reduced time for larger surface areas.

Approach: Design and development of a smart wireless system to read sensor identification information and measurement information of passive surface acoustic wave (SAW) sensors mounted on the aircraft fuselage. The SAW sensor is an inter-digital transducer (IDT) with reflectors coupled to an antenna. The system transmits and receives electromagnetic signals. The transmitted signal is picked up by the antenna, which subsequently, converts into a SAW through the IDTs. These SAWs are reflected back to the IDTs by the reflectors, converted back to an electromagnetic wave and returned to receiver DAQ by the antenna. The acoustic velocity varies as a function of the propagation characteristics of the SAW in the substrate and results in varying time delay of the echoes, which is detected by the system.

Challenges: Sensor tags fabrication, code check analysis from sensors, algorithm development &implementation, frequency spectrum, modulation scheme selection, antenna design and fabrication.

Applications: This passive sensor based smart wireless system can be used for aircraft structural health monitoring and also in other commercial applications.

BACKGROUND

State-of-the-art: Acoustic wave devices have been in commercial use for more than 60 years. Acoustic wave sensors are competitively priced, rugged, very sensitive, and reliable. The acoustic wave sensors are also capable of being passively and wirelessly interrogated (no sensor power source required). As the acoustic wave propagates through or on the surface of the material, any changes to the characteristics of the propagation path, affect the velocity and/or amplitude of the wave. Changes in velocity can be monitored by measuring the frequency or phase characteristics of the sensor and can then be correlated to the corresponding physical quantity being measured.

Scope: Define functional requirement specification and system architecture of smart wireless system and sensor tags, system design & implementation and test plans development for design verification and validation.

Deliverable: Smart wireless system includes a pulsed transmitter, antenna duplexer, time-gated receiver, phase detector, received code analyzer, data storage and passive sensor tags.

Relevance: This project simplifies testing process and reduces time to monitor structural health for large surface areas.

PROJECT EXECUTION

Project Team: NRC-FRL, ASR&D, University of Arizona, University of Liverpool, GE Global Research, McGill University, University of Sherbrooke, CNM Spain, INO and NASA Langley

ROM Cost:

Fiscal year	01	02	03	04
ROM Project Cost ($K)	800	1,200	1,500	
Potential In-kind match($K)	300	600	800	

Potential Funding Sources: NRC-IRAP, DRDC, Bombardier and NASA

POC:
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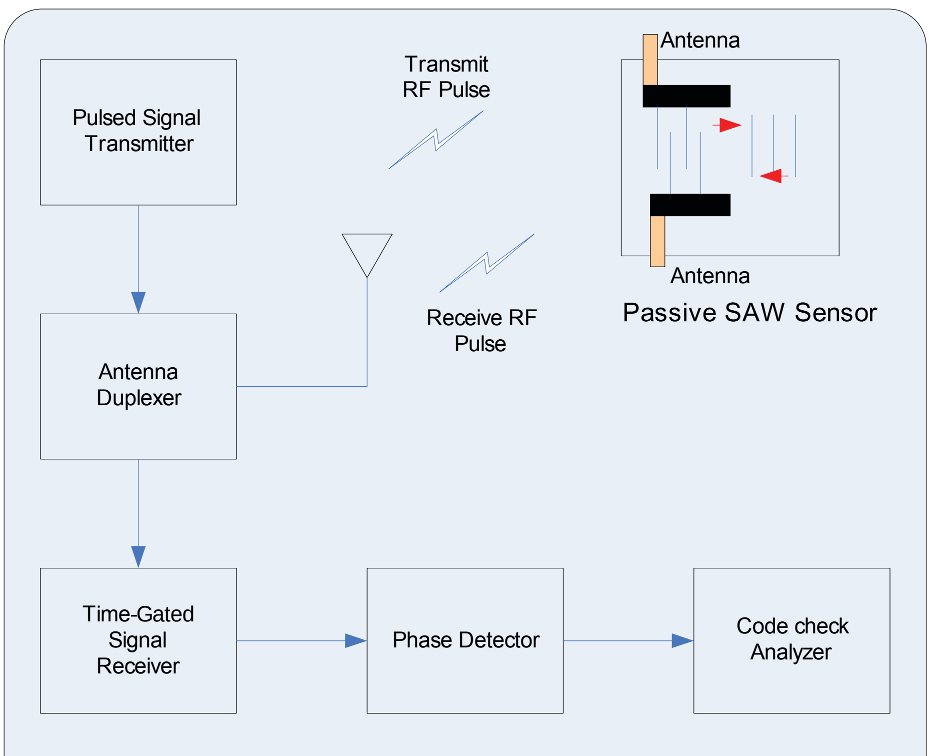


Block Diagram of a Smart Wireless System for SHM

Chapter 7: FINDINGS AND FUTURE ACTIVITIES

The FBW technology promises what aerospace vehicle applications need most: less wires by providing reliable, lower cost, and higher performance alternatives for a vehicle's or program's life cycle. However, the aerospace industry has not yet had the opportunity to immerse itself in this technology in large part because of the perceived, relatively unproven technologies and their reliability in concrete applications.

The main goals of the CANEUS Fly-by-Wireless 2009 workshop were to: (a) stimulate formation of project teams comprised of application/end users and technology providers and (b) to refine the focused projects and pertinent details, identify specific development needs, outline teaming and funding schemes, plan project oversight and execution, and establish milestones from which to gauge success of the projects.

Therefore, hand-in-hand with the creation of an international community and focused projects, the major goal of FBW09 also included identification and development of a coordinated strategy for international investment in FBW technology development for aerospace applications.

FINDINGS AND OBSERVATIONS

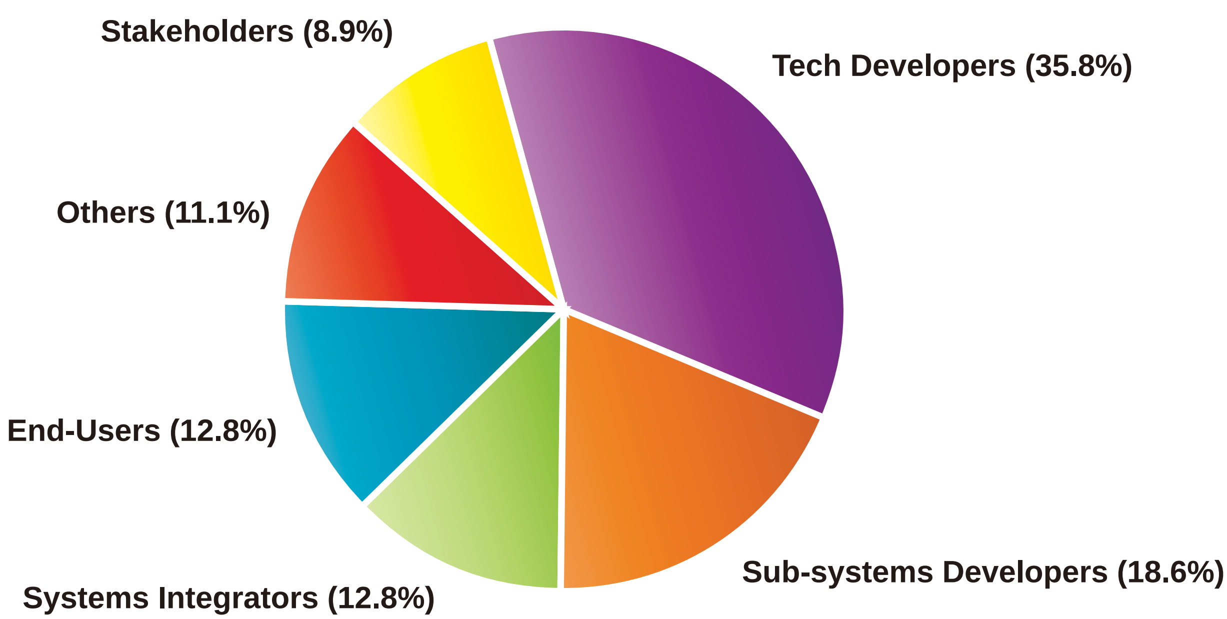
Observation 1: CANEUS International FBW Forum

The CANEUS FBW09 workshop was a significant step towards the creation of an international community by bringing together industry stakeholders; including the new technology developers, funding agencies, systems integrators and aerospace end-users from within Canada, the USA, Europe, and Brazil.

A focused FBW workshop forum is necessary to follow-up the activities and demonstrate successful project results. Perhaps, advanced planning and logistical convenience, would ensure such success.

Observation 2: Case for Consortia and Project Development

The needs by the aerospace industry are clear, and the technology developers are also seeking to find alternatives / solutions to develop several programs.



A. Several MEMS technologies are possibly ready for insertion into the aerospace system. However there appear several efforts underway that seem to be developing in a vacuum, unaware of the advancements being made elsewhere.

B. The technology developers typical "push efforts" makes very difficult to gain the confidence of end-users. In order to gain this confidence, a project demonstration is necessary.

C. On the other hand, the challenge for end-users is to get their needs across to technology developers at the formulation stage.

D. The industrial visits should have taken place right after the end-user needs sessions, which would have allowed workshop participants to define the scope of their projects more accurately.

E. The issue of reliability, several emerging technologies at the proof of concept level are unproven and their reliability is uncertain. Therefore there is a need for a level of assurance with a demonstration project.

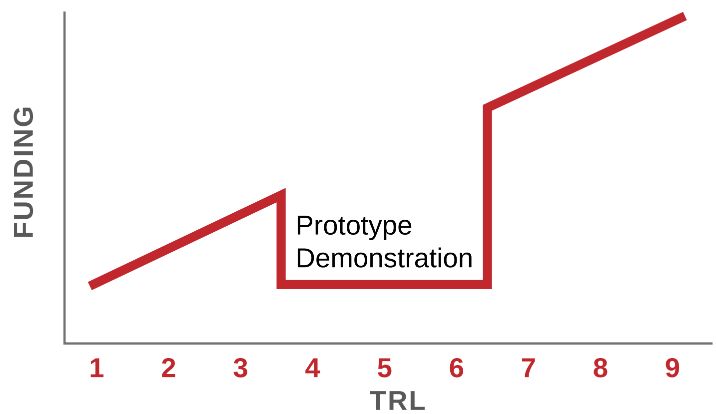
The FBW09 Workshop further emphasized measurable deliverables, namely a set of project "blueprints", for developing the most promising FBW concepts with lasting impact for the aerospace industry.

The five focus areas of the workshop:

- Sensor DAQ Micro-Miniaturization
- Passive Wireless Sensor Tag
- Less–Wire Architectures
- Structural Health Monitoring
- Wireless systems immunity in Electromagnetic Environment

Observation 3: Funding

Another observation relates to the requisite funding for the demonstration of proof of concepts. There appear several resources supporting the efforts for TRL 1-3 at the university level and TRL 7-9 for the product implementation phases. However, funding is needed for prototype demonstration at the TRL 4-6 level, which is important to the infusion of emerging Fly-by-Wireless technology into aerospace product/systems.



Funding agencies are reluctant to take risks because it is difficult for them to measure the actual risk involved, against the potential rewards.

Observation 4: Regulatory and Collaboration Framework

There is also a clear need for a mechanism to facilitate the formulation of collaborative projects from different parts of the world. There are confusing or misleading aspects about what information can be shared and not shared between borders, and is a subject that is often misunderstood. The process is costly, complex and time-consuming, which makes it difficult for even large organisations and well established universities to handle on their own. The draft CANEUS "Technology Charter Agreement" ratified by the appropriate regulatory and export control authorities provides such framework to facilitate these collaborative efforts.

Observation 5: Project Coordination and Reporting

A theme which often returned throughout the workshop was CANEUS's role in the coordination of projects. It was clear from the project leader's reports that effective coordination at the central CANEUS level in both proposal development and implementation, in depth reporting is needed. It was also made clear that increased collaboration between various project groups, on reporting-related issues would also be beneficial.

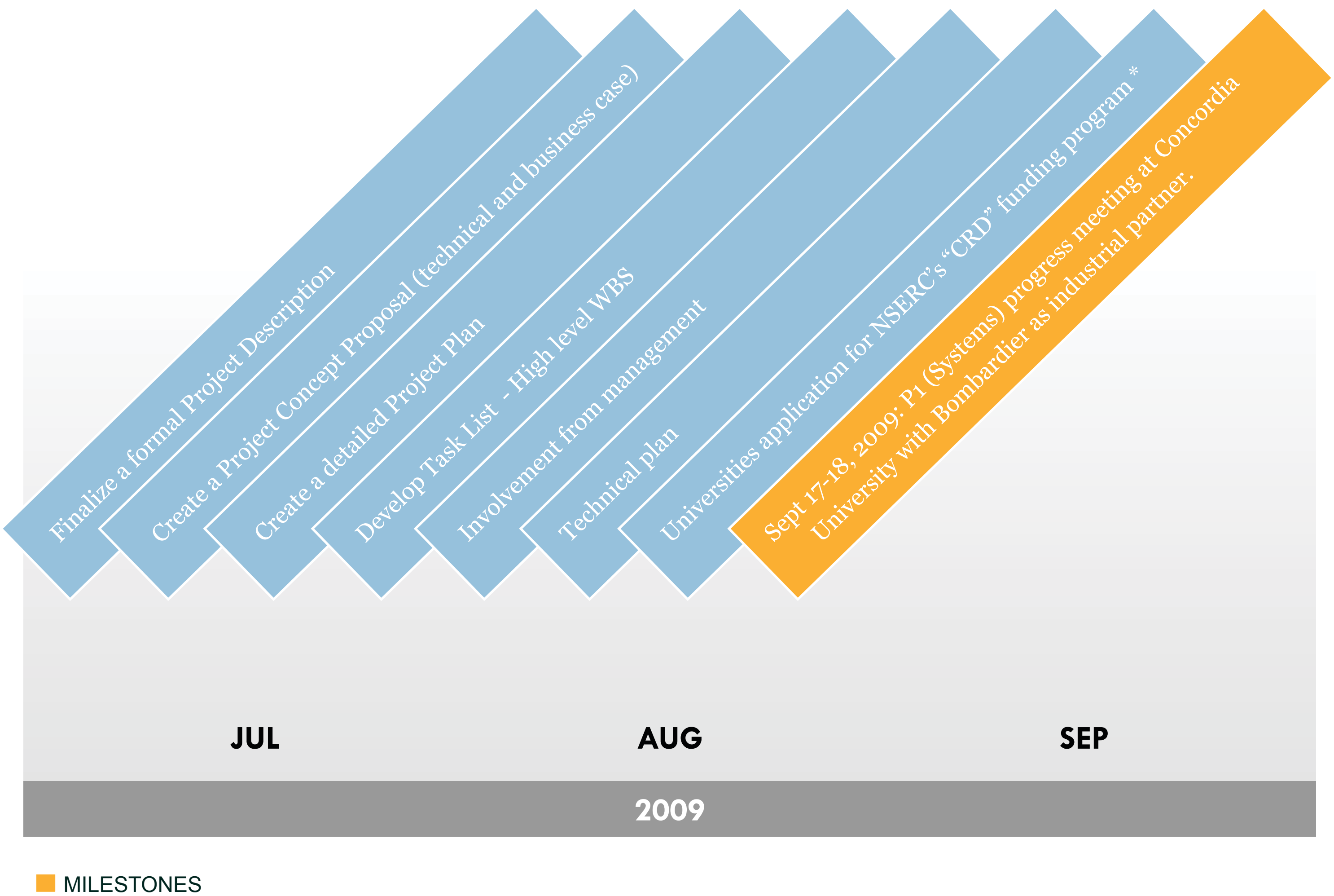
At the CANEUS level it was considered that the meeting of different project teams is needed to occur on a regular basis. It was also considered that effective coordination and harmonization should be addressed in any review of a project's strategies and action plans, as well as strategies for the implementation of project charter agreements.

There is also need for increasing coordination at the project level. For example, this coordination would take place through regular telecons, progress reports, and technical resources to support these activities such as a dedicated project website, for all four project teams.

In summary, the CANEUS FBW09 Workshop exceeded expectations. Not only did we achieve the stated primary objectives, but we went significantly beyond them by creating a unified FBW-Aerospace community across the USA, Canada, Europe and Asia. For its part, Canada and the hosts can be proud of bringing together a truly historic gathering of technical experts and decision makers from across the various participating countries. It is proposed that the following future actions be taken by the Consortium participants:

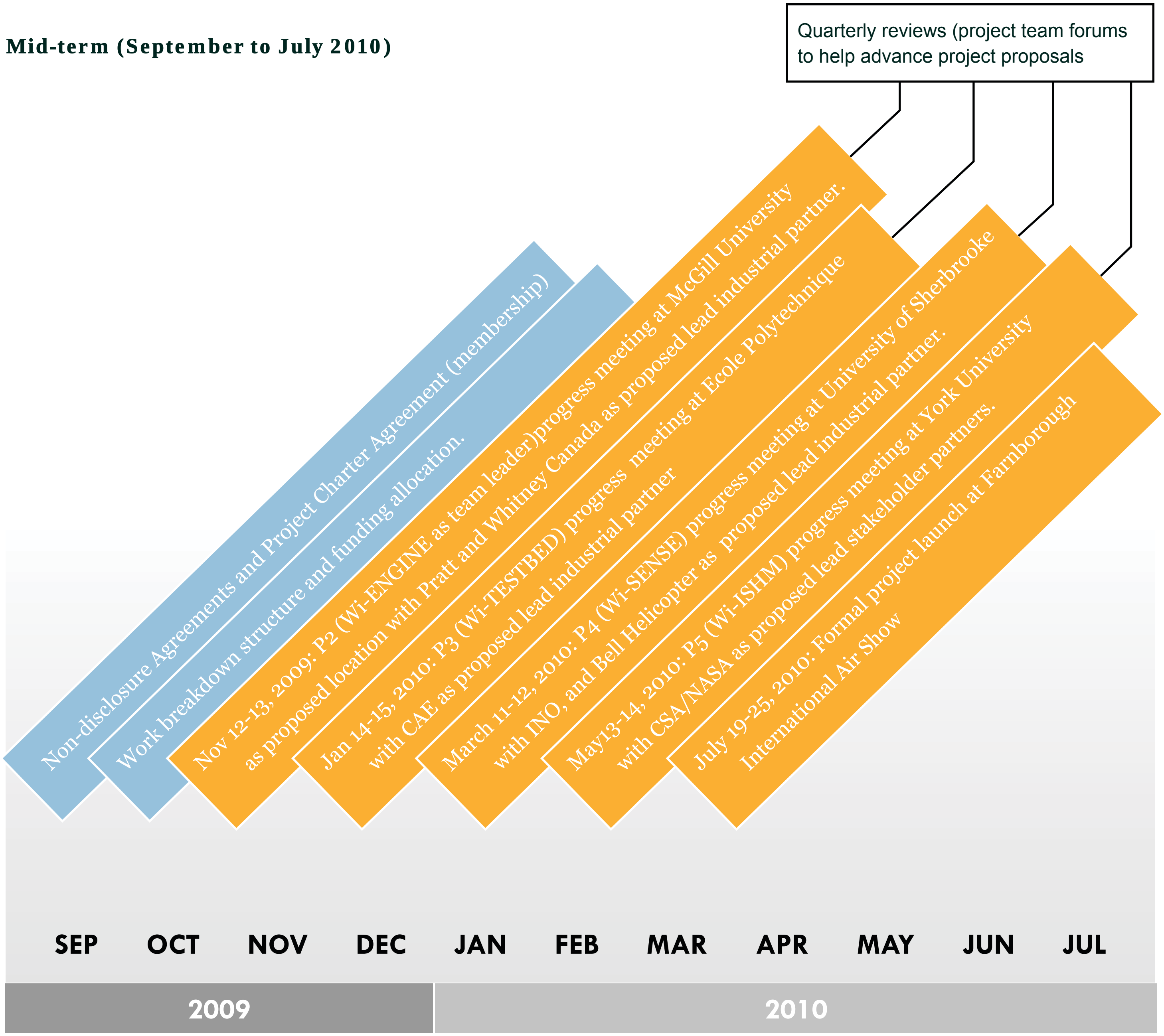
FUTURE ACTIVITIES

Near-term (July to September 2009)

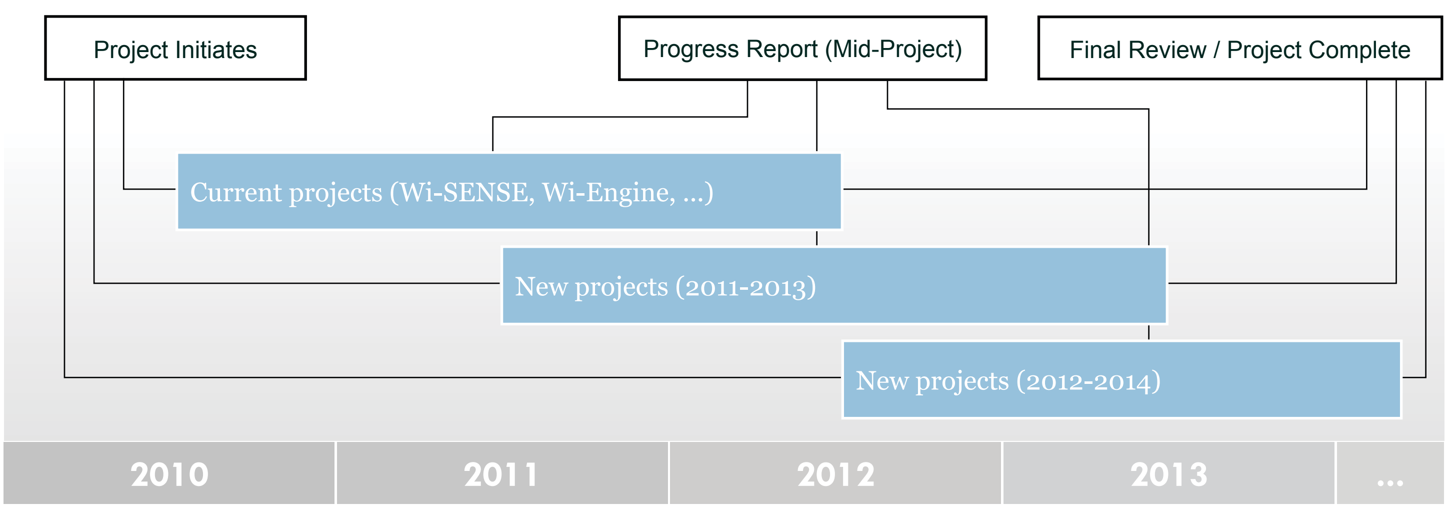


* http://www.nserc-crsng.gc.ca/Partners-Partenaires/programs-programmes/CRDProfile-RDCProfile_eng.asp

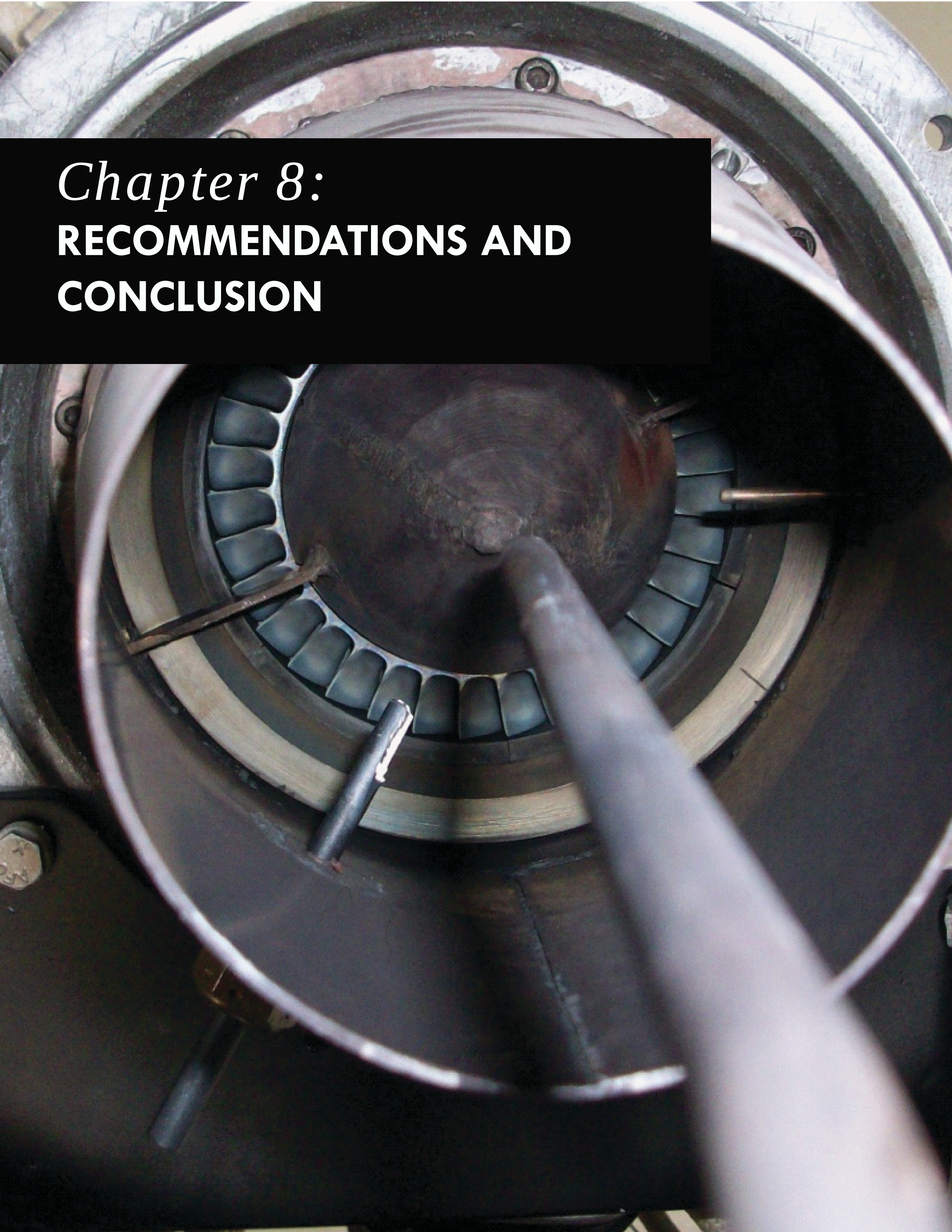
Mid-term (September to July 2010)



Long-term (July 2010 +)



Chapter 8: RECOMMENDATIONS AND CONCLUSION



GOALS OF THE FBW WORKSHOP AND REPORT

The core premise of this CANEUS FBW09 workshop was that complementary skill sets from across several organizations and countries are needed to rapidly and cost-effectively transform emerging FBW concepts into practical Aerospace systems. By pooling resources, whether funds, research, materials, personnel, etc, we need to work together on high-risk, high-cost efforts which share a common vision and goal.

RECOMMENDED FUTURE ACTIONS

The CANEUS FBW09 workshop concluded with a set of recommendations to finalize the "blueprints" for a set of projects aimed at practical Aerospace FBW development through to the level of a high-level system prototype. The project proposal document is expected to provide future investors, whether agency program managers or funding agencies, with an authoritative and comprehensive plan for technology development. Several end-user needs representing the aeronautics, space and defence industry were identified and defined in Chapter 3 and then several promising concepts were presented in chapter 8. These needs included the following:

1. Analyze the end-user areas of complementary, core expertise, which can be seamlessly integrated into the "FBW technology pipeline" for Aerospace Systems.
2. Formulate rapid demonstration and test opportunities through consortia projects that can advance FBW technology development far more rapidly than is currently the case. In this way, there is a dual benefit of realizing the Return-on-Investment (ROI) quicker as well as "building in" reliability and robustness into Aerospace industry at a relatively early stage of development.
3. Set up international project charter agreements that will serve as the basis for future collaborations and ensure the free flow of Aerospace FBW technologies between participating countries.
4. Identify and secure funding to ensure successful project implementation . This is reliant on securing sufficient resources for prototype demonstration at the TRL 4-6 level, and thus the successful infusion of emerging Fly-by-Wireless technology into aerospace applications.

The major areas which the workshop was seeking to address were:

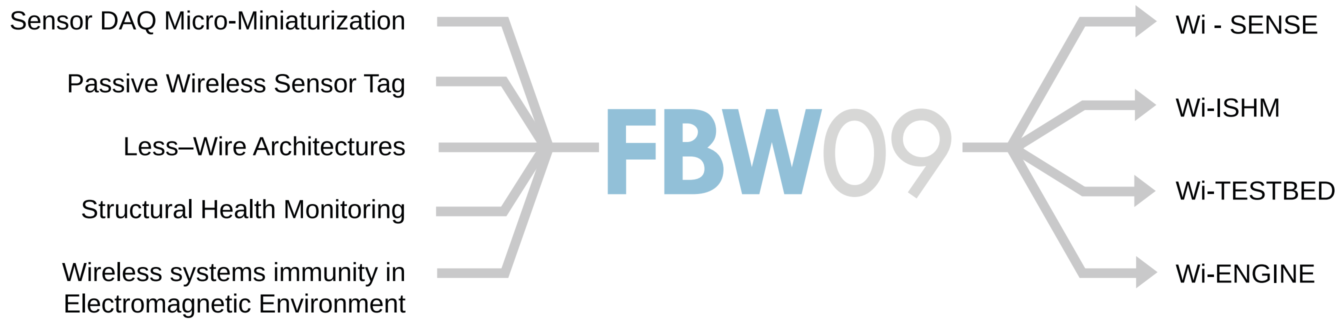
- Sensor DAQ Micro-Miniaturization
- Passive Wireless Sensor Tag
- Less–Wire Architectures
- Structural Health Monitoring
- Wireless systems immunity in Electromagnetic Environment

GOALS OF EACH MAJOR AREA AND PROJECTS THAT EMERGED

- Sensor DAQ Micro-Miniaturization and Passive Wireless Sensor Tag: To simplify the testing process, enhance the accuracy of test results, and reduce test time for larger surface areas.
  Proposed project: Wi-SENSE

- Less–Wire Architectures : To implement a wireless testbed to evaluate the most appropriate protocol for critical communications with airborne applications; identify key performance nodes, and resistance to EMI/EMP/HIRF; also address the testing needs such as the robustness of systems (ie. hacking, security); interference between planes (equipment, personal devices); environmental (external, high altitude reliability); performance, power, protection of critical nodes; static and dynamic testing; and certification testing (encryption, etc)
  Proposed project: Wi-TESTBED

- Structural Health Monitoring : To ameliorate the structural health monitoring of the main fuselage and/or the main structure.
  Proposed project: Wi-ISHM



- Wireless systems immunity in Electromagnetic Environment : the aim is to replace the wiring harness and sensors currently used for engine monitoring with a wireless system that reduces the wire, wire connectors, wire holds, weight, component volume, system cost and maintenance cost. Through the implementation of a wireless system, the reliability and manufacturability will also be improved. **Proposed project: Wi-ENGINE**

RECOMMENDATIONS

Based on the presentations by end-users, tech-developers and funding agencies; subsequent discussions; and reports by the project team leaders, the participants developed the following recommendations for accomplishing the near to long term activities:

I. Full-Scale Project Proposal Development:

In the interests of increasing the efficiency of advancing the four projects with requisite funding in place, the following steps were proposed:

a. Complete 2-page project proposal according to the project development template;

b. Identify funding sources to accomplish the feasibility study and project proposal within 90 days;

c. Refine the information they need in order to assess implementation and outcomes

d. Formulate project team charter agreements and get their approval from management of respective organizations.

II. Focus on end-user needs and business case

Project scope and framework should relate to the specific requirements defined by the end-user, both providing information to support the formulation process, work-breakdown structure and milestones to implement project and their significance to the consortium activities. With this in mind, after the first version of the project proposal, teams should disseminate the relevant parts of the project proposal and an analysis of their achievements to all projects team members.

III. Develop entire system architecture:

Although the goal of the FBW09 Workshop was to develop a set of projects, these projects also had to be defined in such a way that they could be mapped into a complete system architecture. The first is to create a set of project concepts with specific business cases, as well as an approach that meets the needs of the specific end-user groups which are described in Chapter 3. The second is to provide mechanisms for extending the system into a set of subsystems. These mechanisms are discussed in chapter five.

IV. Project Coordination at CANEUS international Central level:

The CANEUS International organization should consider:

- Establishing a dedicated website and communication tool to develop and promote a streamlined project reporting agenda across four projects, taking account of the issues raised in each project teams, developments requested by team leaders, and issues discussed periodically.

- The FBW Consortium leaders group would comprise of a Project Team Leader from each team, supported as necessary by other appropriate experts. It is anticipated that the group and CANEUS project support office would work together to develop proposals which would be submitted to various funding agencies.

V. Coordination at the Project Team level:

At the project team level, members should establish a mechanism appropriate to team requirements to ensure coordination of all activities and it's implementation with other teams, including reporting. Each Project Team is able to directly communicate with other Project Teams and/or CANEUS administration without going through an extensive hierarchy.

VI. Review of FBW Consortium Areas:

The FBW Consortium should revisit the previously defined areas, in order to support activities from this workshop. The topics should be revised in the light of experience from the projects and other new developments reviewed and disseminated at FBW09 workshop.

VII. Web portal for each project:

The project leaders and CANEUS secretariat should work together to develop and maintain a single website for each project team that addresses key issues related to that project and also links to existing resources, as well as results of the work in progress.

VIII. Dissemination of workshop results:

CANEUS and the Chairs of the workshop FRL-IAR-NRC are requested to disseminate the results of the workshop widely. Furthermore, the report should be provided to stakeholders and potential funding agencies worldwide, and with a request that the report be circulated to the various program managers and to their regional offices. For example:

- European Space Agency
- European Union 7th Framework
- International Organizations (FAA, IKO, and WRC)
- The US: Air Force, NASA, NIST, DARPA, ARMY
- International Aerospace end-users (Boeing, Lockheed Martin, EADS, Bombardier, Embrear, Mitsubishi, and others.)

IX. Implementation Plan

The following actions are necessary for the successful implementation of the recommendations outlined above and must be followed using the near and long term timeline:

- Undertake a feasibility study for each project.
- Develop the full scale project proposal and implementation plan.
- Organize the next workshop within twelve months and create follow up reports shortly after.

CLOSING REMARKS

Wireless technology is of strategic importance for the aerospace industry. As a result, individual organizations on the international scale are attempting to advance in this field in a very fragmented way. The CANEUS International consortium has taken the first steps in bridging these gaps by providing concrete timelines for achieving significant milestone and ensuring the propulsion of the FBW technology for aerospace applications. The consortium is uniquely placed as an organism that brings together key stakeholders like end-users, systems integrators and systems developers. As mentioned previously, the only way to move forward is to establish cohesion and collaboration. It is only by bringing together the key players and stakeholders from different countries and industries where the fly-by-wireless vision will become a reality.

Appendix A. *Workshop Agenda*

See Next Page.

	Monday June 8	**Tuesday** June 9	**Wednesday** June 10
	Plenary & End User Briefings	**Technology Provider Briefings**	**Project Development, Implementation and Success Criteria**
07:30-08:30	Registration		
08:30-09:00	**Session 1** Welcome, Introduction and Workshop Overview	Keynote Address **Fu-Kuo Chang** SCL Stanford University	Keynote Address **Bob Walker** DRDC-DND
09:00-09:30		**Session 7** Sensor DAQ Micro-Miniaturization Passive Wireless Sensor Tag Less–Wire Architectures	**Session 11** Overview of Projects
09:30-10:00	Keynote Address **Mairead Lavery** Bombardier Aerospace Montreal		
10:00-10:30	Coffee Break	Coffee Break	Coffee Break
10:30-11:30	**Session 2** Raison d'être of FBW Consortia & Projects	**Session 8** Sensor DAQ Micro-Miniaturization Passive Wireless Sensor Tag Less–Wire Architectures	**Session 12** Funding Opportunities
11:30-12:00	**Session 3** Overview of Key Issues (IP, Funding, NDA and Export Control)		
12:00-13:30	Keynote Address + Lunch **Radoslaw R. Zakrzewski** Goodrich Corporation	Keynote Address + Lunch **Radislav A. Potyrailo** GE Global Research Center NY	Keynote Address + Lunch **Jim Brockbank** Export Development Corporation
	End User Briefings	**Technology Provider Briefings**	**Project Reports**
13:30-14:00	Keynote Address **Victor Giurgiutiu** Air Force Office of Scientific Research (AFOSR)	Keynote Address **Tribikram Kundu** University of Arizona	Keynote Address **Duane Cuttrell** LMCO - Skunk Works
14:00-15:00	**Session 4** Structural Health Monitoring **+ Round-table Discussion**	**Session 9** Structural Health Monitoring Instrumentation Wireless systems immunity in Electromagnetic Environment	**Session 13** Project Success Criteria **Linda Beth Schilling** and **Frank Barros** ATP-NIST, Dept. of Commerce, USA
15:00-15:30	Coffee Break	Coffee Break	Coffee Break
15:30-16:00	Keynote Address **John McGraw** FAA	Keynote Address **Minoru Taya** University of Washington	**Session 14** Project Summary
16:00-17:00	**Session 5** Passive Wireless Sensor Tag and Sensor DAQ Micro-Miniaturization **+ Round-table Discussion**	**Session 10** Structural Health Monitoring Instrumentation Wireless systems immunity in Electromagnetic Environment	**Session 15** CEO/CTO Expert Panel Discussion
17:00-17:30	**Session 6** Wireless systems immunity in Electromagnetic Environment (HIRF, Lightning etc) **+ Round-table Discussion**		Conclusion
17:30-19:00	Student Poster Session + Wine and Cheese	Student Poster Session + Wine and Cheese Banquet Keynote Address **Francois Caza** Bombardier Aerospace	Project Group Leadership Dinner

Appendix B. *Industrial Tours and Relevance to Workshop*

Technical tours to local end-user and technology provider facilities showcased a cross-section of practical solutions relevant to the problems being addressed in the CANEUS FBW09 Workshops.

CANADIAN SPACE AGENCY

(Thursday AM)

The Canadian Space Agency directs its resources and activities through four key Programs:

- Earth Observation
- Space Science and Exploration
- Satellite Communications
- Space Awareness and Learning

BOMBARDIER AIRCRAFT MANUFACTURER

(Thursday PM)

The Montreal visit to the Bombardier Aerospace facilities included a visit of the Commercial aircraft – the new CSeries program, CRJ Series and Q-Series aircraft families. Participants also saw the aircraft services and training centers which included a viewing of aircraft parts, as well as maintenance and training facilities.

CAE ELECTRONICS SIMULATOR

(Friday AM)

The Montréal visit to the CAE's world headquarters included the engineering and production facilities (the main plant for design and manufacturing of full flight simulators).

Following a short corporate presentation on CAE in our auditorium, participants were invited to tour the engineering offices and labs where CAE designs and integrates the avionics systems for high-fidelity simulators. They then toured the main manufacturing facilities where CAE produced over 50 flight simulators in 2008. Participants also had an opportunity to come aboard the first B787 flight simulator as the test pilot teams validated the simulator prior to customer delivery later this summer. The tour was hosted by several of CAE's avionics experts, and later answered questions on the latest advances in avionics simulation.

Appendix C. *Workshop Participants and Contributors*

WORKSHOP CHAIRS

- Milind Pimprikar, CANEUS International, and Centre for Large Space Structures & Systems - Founder & Chairman
- Roy Vestrum, NRC-IAR-FRL – Organizing Committee Chair
- David Russel, National Research Council Canada - Technical Co-Chair
- Jim Castellano, Industry Canada - Technical Co-Chair
- Jules O'Shea, École Polytechnique de Montreal - Hosting Chair

PARTNERS

- Industry Canada
- National Research Council Canada
- Pratt & Whitney Canada
- Bombardier, Aéronautique
- Canadian Space Agency
- RESMIQ
- IEEE Aerospace and Electronics Systems Society

HOSTS

- CANEUS International
- Center for Large Space Structures and Systems
- École Polytechnique de Montreal

SPEAKERS

- Christophe Guy, Director, École Polytechnique de Montreal
- Milind Pimprikar, Founder & Chairman, CANEUS International
- Rick Earles, Executive Director, CANEUS USA Inc.
- Todd Farrar, Business Acceleration Manager, Dawnbreaker, Inc., NY
- Suzanne Benoit, Aéromontreal
- George N. Grammas, Partner, Squire, Sanders & Dempsey L.L.P. Washington, DC
- Radoslaw R. Zakrzewski, Sensors and Integrated Systems, Goodrich Corporation, USA
- Victor Giurgiutiu, Structural Mechanics program manager, Air Force Office of Scientific Research (AFOSR)
- William "Cy" Wilson, NASA Langley Research Centre, Virginia
- Hugh HT Liu, Institute for Aerospace Studies University of Toronto
- Keith Meredith, Aeroinsight (TBC) DPHM Canada Roadmap
- Nezih Mrad, Defence Scientist, Defence R&D Canada (DRDC), Department of National Defence (DND)
- Fidele Moupfouma, Chief Aircraft Electromagnetic Hazards Protection Engineer, Bombardier
- Robert S. Walker, Assistant Deputy Minister and CEO, DRDC-DND (Defense Research and Development Canada- Dept. of National Defense)
- Duane Cutrell, F-35 Joint Strike Fighter, LMCO-Skunk Works

- Fassi Kafyeke Strategic and Technology Director, and Chief Engineer, Bombardier Aerospace
- Fu-Ko Chang, Professor and Director, Structures and Composites Laboratory, Stanford University
- Jacqueline Hines, CEO, Applied Sensor Research & Development Corporation
- Donald C. Malocha, Professor, School of Electrical Engineering, University of Central Florida
- Eamonn Fearon, Centre Manager, Lairdside Laser Engineering Centre,University of Liverpool
- Ahmadreza Tabesh, and Luc G. Frechette, University of Sherbrooke
- Francis Picard, INO (National Optic Institute)
- Radislav A. Potyrailo, Principal Scientist , GE Global Research Center, NY
- Tribikram Kundu, Chairman, SPIE SHM Conferences, University of Arizona
- Cheng-Kuei Jen, IMI (Industrial Materials Institute)
- Carles Ferrer, CNEM (National Center of Microelectronics) Spain
- Anader Benyamin-Seeyar, IEEE Montreal
- Douglas Goodman, CEO Ridgetop Group Inc.
- Karim Allidina and Mourad N. El-Gamal, McGill University
- Yvon Savaria, Guchuan Zhu, Mohamad Sawan, Normand Bélanger, École Polytechnique de Montréal
- Maurizio Dacunha, University of Maine
- David Russel, Flight Research Laboratory, Institute of Aerospace Research, National Research Council Canada
- Brian McCabe, Sikorsky Aircraft
- Fidele Moupfouma, Bombardier Aerospace Core Engineering, Montreal
- Gabriella Graff-Innes, CCC (Canadian Commercial Corporation)
- Denis Godin, NSERC (Natural Sciences and Engineering Research Council), Canada
- Carlos Trindade, CRIAQ (Consortium for Research and Innovation in aerospace in Quebec)
- Yves Plourde, IRAP(Industrial Research Assistance Program), Canada
- Jim Brockbank, VP Transportation, Export Development Corporation
- Linda Beth Schilling, NIST (National Institute of Standards and Technology) - Technology Innova-tion Program
- Frank Barros, NIST (National Institute of Standards and Technology)- Small Business Innovation Research
- Adarsh Deepak, CEO Science and Technology Corporation
- Roy Vestrum, Flight Research Laboratory, Institute of Aerospace Research, National Research Council Canada

SESSION CHAIRS AND CO-CHAIRS

- Jules O'Shea, Professor, École Polytechnique de Montreal
- Roy Vestrum, Flight Research Laboratory, Institute of Aerospace Research, National Research Council Canada
- Andre Bazergui, P-DG/CEO, CRIAQ, Consortium for Research and Innovation in Aerospace in Quebec
- Wanping Zheng, Canadian Space Agency
- Yvon Savaria, Chairman, Electrical Engineering, École Polytechnique de Montreal
- Patrice Masson, Professor, University of Sherbrooke
- Claude Lavoie, Bombardier Aerospace
- David Russel, Flight Research Laboratory, Institute of Aerospace Research, National Research Council Canada
- Richard Hurteau, Professor, Electrical Engineering , École Polytechnique de Montréal
- Sonia Blanco, Researcher MOMS, INO, (National Optic Institute)
- Steve Totolo, Instrumentation Specialist, IAR-NRC (Institute of Aerospace Research, National Research Council Canada)
- Laurent Lamarre, Researcher, IREQ (Hydro-Quebec),

Chair IEEE

- Pascal Hubert, McGill University
- Nezih Mrad, DRDC-DND (Defense Research and Development Canada- Dept. of National Defense)
- Jureck Sasiadek, Carleton University
- Alain Bolduc, CMC
- Carlos Trindade, CRIAQ (Consortium for Research and Innovation in aerospace in Quebec)
- Rick Earles, CANEUS USA
- Peter Eggleton, Telligence Group
- Anader Benyamin-Seeyar, IEEE Montreal
- Suzanna Benoit, CEO-AERO Montreal

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- Karim Allidina, McGill University
- Yves Audet, École Polytechnique de Montréal
- William Beacham, Pratt & Whitney
- Paraag Borwankar, Pratt & Whitney Canada
- Stephane Bucaille, AREVA
- Soumaya Cherkaoui, University of Sherbrooke
- Somen Chowdhury, Bell Helicopter Textron Canada Ltd.
- Peter Eggleton, TELLIGENCE Group
- Steven Ford, CMC Electronics
- Syed Rafay Hasan, École Polytechnique de Montréal
- Japhet Honvo, École Polytechnique de Montréal
- Seid Mohammad Saleh Hosseini, École Polytechnique de Montréal
- Richard Hurteau, École Polytechnique de Montréal
- Jim Jarvo, Pratt & Whitney Canada
- Alejandro Jimenez, NASA-JPL
- Vincent Lacasse, CEL Aerospace
- David Lalonde, École Polytechnique de Montréal
- Laurent Lamarre, IEEE Montreal, IREQ
- Claude Lavoie, Bombardier Aerospace
- Wei Lin Liu, McGill University
- Ali Mahvash, École Polytechnique de Montréal
- Marc-Andre Marceau, École Polytechnique de Montréal
- Ahmed Maslouhi, Université de Sherbrooke
- Patrice Masson, Université de Sherbrooke
- Mohammed Reza Mofakhami, Bombardier Aerospace
- Abdelhak Oulmane, École Polytechnique de Montréal
- Ricardo Rulli, Embraer
- Chung Poon, Ryerson University
- Jureck Sasiadek, Carleton University
- Jeanne Shih, McGill University
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- Steven Totolo, National Research Council
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- Miguel Velez-Reyes, University of Puerto Rico
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- Guchan Zhu, École Polytechnique de Montréal

SUPPORT STAFF

- Sudarshan Martins, Canadian Space Agency
- Frederick Mathieu, Canadian Space Agency
- Maxime Pepin-Thivierge, Canadian Space Agency
- Alexandre Mousseau, Canadian Space Agency
- Jean-Francois Lambert, Canadian Space Agency

EXHIBITORS

Opal-RT Technologies Inc.

Opal-RT Technologies (www.Opal-RT.com) is the leading developer of open PC-Based Real-Time Digital Simulators and Hardware-in-the-Loop testing systems for avionic, electrical, power electronic and electro-mechanical systems.
All Opal-RT Simulator products are built using commercial-off-the-shelf PC hardware and leverage the power of RT-LAB – Opal-RT's flagship Real-Time Simulation technology that has revolutionized the way model-based design is performed. RT-LAB's flexibility and scalability allow it to be used in virtually any simulation or control system application, and to add computing power to simulations where and when it is needed.

CS Communications

CS Canada is a subsidiary of a large group, CS Communication & Systems, based in France. The CS Group is a major service supplier to Airbus, Thales, Hispano Suiza, and the French Armed Forces amongst others . Its Aeronautics Division has 250 software engineers, specialists in control system software design. CS also offers access to an internal source of low-cost software development/testing capabilities with its Romanian subsidiary, for the benefit of its customers. CS Canada works on firm-fixed price or on consulting basis. We also offer DO-178B consulting and training.
CS Communications and Systems Canada is a System Integrator, and embedded software solution provider, for the Space, Aeronautics, Defence and Mass Transportation industries.

We deliver services, dedicated solutions and off-the-shelf products that enable our customers to reduce costs, risks and delivery time for their products and systems. Our innovative systems provide our customers with long-term competitive advantages. We specialize on firm, fixed price offers for critical embedded software, simulation systems and satellite control systems.

McGill University

Miniature Sensors and Low Interference Wireless Systems for Aerospace Applications

Micro-electromechanical systems (MEMS) are very small mechanical structures capable of functioning as sensors, actuators, resonators, and more. They are manufactured using technologies and materials similar to those used to fabricate integrated circuits.

The MEMS process developed by our research group (patented) is compatible chemically and thermally with state-of-the-art IC fabrication, enabling micro/nano sensors to be directly "grown on top" of the electronic chips, resulting in smaller size and weight, lower cost, lower power, and higher functionality and performance. A packaging solution enabling device packaging at the wafer level is also reported. This is important in order to increase the manufacturing yield.

This group has also developed a prototype wireless interface for an ultrasonic sensor used to detect changes in the thickness of an aircraft stabilizer due to corrosion. Ultrasonic echoes obtained from a 1.5 mm thick aluminum stabilizer are reported to demonstrate the operation of the wireless interface. The system had two main limitations: 1) it was large, and 2) it used a narrowband wireless modulation scheme that may interfere with existing aircraft systems.

Hoskin Scientifique

Hoskin Scientific Limited has been supplying testing and monitoring instruments since 1946. Although our range is broad, we focus on three major markets listed below.

- Geotechnical & Materials Testing- Testing Equipment for soil, asphalt, petroleum, concrete and cement.
- Environmental Monitoring- Sampling and monitoring instruments for air, water, and soil for the environmental, agricultural, mining and forestry markets.

- Test & Measurement Instrumentation- The Test and Measurement Instrumentation division has sensors, transducers and instrumentation for industry, manufacturing, research & development, and factory automation.

Technologies Harness Scanner Inc.

Technologies Harness Scanner is a provider of automated solutions to audit, improve and maintain onboard electrical systems over their entire life cycle. Our generic wireless Harness Scanner system permits a single operator to verify the in-situ configuration of complete electrical sub-system in a few minutes and determine fault location. Our patented processes have been designed to integrate with CAD design, improve electrical harness/system manufacturing, validate onboard installation/retrofit and facilitate diagnostic for fleet operators.

TODAY, use our products to improve the productivity of your existing FLY-BY-WIRE platforms. TOMORROW, rely on our avionics and wireless expertise to design your FLY-BY-WIRELESS projects.

Appendix D. *Research-in-progress*

STUDENT PROJECTS

Vibration-Based Energy Harvesting For Wireless Sensor Networks
Nezih Mrad
Defence Scientist
Defence R&D Canada (DRDC), Department of National Defence (DND)

Electrical Characterization of Composites for Aircraft Fuselage
William Tse
Research Director: Prof. Jean-Jacques Laurin

Detection of Hidden Corrosion by Pulsed Eddy Current Using Time Frequency Analysis
Seid Mohammad Saleh Hosseini
Under supervision : Professor Aouni Lakis

Development of Intelligent Health Monitoring System for Rotating Machinery and Structural Components
Ali Mahvash and Abdelhak Oulmane
Under Supervision of Prof. Aouni A. Lakis, Ph.D.

Smart Bird
Japhet HONVO
École Polytechnique de Montréal

Electromagnetic and Thermodynamic Study of Electrical Current Return Networks for Aircrafts with Composite Fuselage
David Lalonde and Frédéric Sirois
Departement of Electrical Engineering
École Polytechnique de Montréal

Low Power Ultra Wideband Circuits
Karim Allidina
Department of Electrical and Computer Engineering
McGill University, Montreal, Canada

Appendix E. *TAA Template*

See Next Page.

Fly-By-Wireless Charter Group

Cooperation Pursuant To

TECHNICAL ASSISTANCE AGREEMENT

(TA _______)

By and Among

CANEUS USA Inc.
a 501(c)(3) non-profit corporation under the laws of Ohio, USA,
Applicant, Registration Code: **[PROVIDE]**

And

Company A
a company under the laws of Delaware, USA

And

CANEUS International
a non-profit organization under the laws of Canada

And

Company B
a company under the laws of Canada

And

Organization C
a company under the laws of Canada

For the export of technical data and defense services in the context of cooperation
for the development of Fly-By-Wireless standards, definitions and specifications for use by:
End-User 1
End-User 2
End-User 3

THIS TECHNICAL ASSISTANCE AGREEMENT (this “Agreement” or “TAA”) is entered into on this _____ day of _________________, 2009 (the “Effective Date”) by and among:

CANEUS USA Inc., formed under the laws of Ohio, USA, with offices at 140 Queens Lane, Canfield, OH USA 44406, USA (“CANEUS USA”);

Company A, formed under the laws of .....(“...”);

CANEUS International, formed under the laws of Canada with offices at 431 Brock Avenue, Montreal, Quebec, Canada H4X 2G6 (“CANEUS International”);

Company B, formed under the laws of .....(“...”); and

Organization C., formed under the laws of ...(“....... “);

each individually referred to as “Party” or collectively as “Parties.”

Recitals:

A. PURPOSE

The Parties and Government End-Users (defined below) are the charter members of the CANEUS Fly-by-Wireless Sector Consortium (the "Consortium"). The purpose of the Consortium is to minimize cables and connectors and increase functionality in aerospace applications, including for spacecraft, through micro- and nano-technology ("MNT") items to provide reliable, lower cost, modular, and higher performance alternatives to wired data connectivity to benefit the entire vehicle/program life-cycle.

The purpose of this TAA is to allow the Parties to collaborate on the development of standards, definitions and specifications for Fly-By-Wireless solutions to be used in spacecraft applications by or for the following U.S. Canadian, Europe, Brazil Government end-users: ... (collectively, the "Government End-Users"). The MNT technology and possible Fly-By-Wireless solutions are at an early stage of technology readiness. A variety of potential applications are expected to surface beyond use in the space program. For example, the Parties intend that the standards, definitions and specifications for Fly-By-Wireless solutions will be used or adapted for use in civilian aerospace applications.
[PLEASE NOTE THAT WE HAVE PURPOSEFULLY EXCLUDED MILITARY END-USES FROM THIS DESCRIPTION]

B. ROLES AND RESPONSIBILITIES

1. Applicant and Licensor: CANEUS USA

   CANEUS USA is a 501(c)(3) non-profit corporation focused primarily on transitioning MNT into aerospace applications in a rapid and cost-effective manner. CANEUS USA brings together MNT developers, aerospace end-users, governmental policy makers and investors from across the world. It provides a platform for coordinated investment and collaborative development of aerospace MNT by identifying and nurturing complementary core competencies.

   CANEUS USA serves at the project manager for the Consortium and will **[PROVIDE ADDITIONAL DESCRIPTION OF CANEUS USA'S ROLE].**

2. Other U.S. Licensor: Company A

   Company A is well-known as one of the world's leading aerospace companies and manufacturer of ....**[PROVIDE DESCRIPTION OF COMPANY A's ROLE]**

3. Foreign Licensees

   a. CANEUS International
      CANEUS International Inc. is a non-profit organization that seeks to benefit the aerospace industry by fostering international public/private partnerships between industries, research laboratories, and government stakeholders. CANEUS aims to mitigate the high cost and risk of advanced technology development by defining and executing these projects and initiatives through collaborative

partnerships. CANEUS International serves the Consortium Coordinator and **[PROVIDE ADDITIONAL DESCRIPTION OF CANEUS INTERNATIONAL'S ROLE]**

b. Company B
Company B is well-known as one of the world's leading aerospace companies and manufacturer of ....**[PROVIDE DESCRIPTION OF COMPANY B's ROLE]**

c. Organization C
Organization C is well-known as one of the world's leading aerospace companies and manufacturer of ....**[PROVIDE DESCRIPTION OF ORGANIZATION C's ROLE]**

4. Sub-licensees.

At this time, the Parties do not intent to engage any sublicensees under this TAA. The addition of sublicensees will be allowed only by amendment to this Agreement.

5. Government End-Users

a. USA.....
is an agency of the United States government, responsible for the nation's public program and responsible for long-term civilian and military aerospace research. XX will assist the Consortium in the formulation of industry needs and applications.

b. Canada ....
is an agency of the Canadian government, responsible for the nation's public program and responsible for long-term civilian and military aerospace research. XX will assist the Consortium in the formulation of industry needs and applications.

c. Europe........
is an agency of the UK government, responsible for the nation's public program and responsible for long-term civilian and military aerospace research. XX will assist the Consortium in the formulation of industry needs and applications.

C. SCOPE OF TECHNICAL DATA AND DEFENSE SERVICES

The scope of this TAA is to authorize the export and reexport of Technical Data and Defense Services, as those terms are defined below, by and among members of the Consortium in connection with the development of Fly-By-Wireless solutions for use in aerospace and space applications as set forth in Annex A, Scope Statement, attached hereto.

NOW, THEREFORE, in consideration of the above premises and the mutual promises and understandings set forth in this Agreement, and intending to be legally bound, the Parties agree as follows:

Article I

Definitions

Section 1.01 The term **"Applicant"** means CANEUS USA.

Section 1.02 The term **"Approved Program"** means the development of Fly-By-Wireless solutions to be used in spacecraft and aerospace applications by or for the following Governments End-Users.

Section 1.03 The term **"Defense Article"** means any equipment that is identified on the United States Munitions List ("USML"). See 22 C.F.R. § 120.6.

Section 1.04 The term **"Defense Service"** means the furnishing of assistance, including training, to foreign persons whether in the United States or abroad, in the design, development, engineering, testing, production, processing, manufacture, assembly, use, operation, overhaul, repair, maintenance, modification, reconstruction, demilitarization or destruction of a Defense Article or related Technical Data specifically identified by the USML, or the furnishing to Foreign Persons of any Technical Data controlled under the USML. See 22 C.F.R. § 120.9.

Section 1.05 The term "**DDTC"** means the U.S. Department of State, Directorate of Defense Trade Controls or any successor agency responsible for the administration of licenses for the export of Defense Articles, Defense Services, and Technical Data. See 22 C.F.R. § 120.12.

Section 1.06 The term **"Dual National"** means an individual that holds nationality from the country of a foreign Licensee and one or more additional foreign countries.

Section 1.07 The term **"Foreign Person"** means any person who is not a citizen or national of the United States unless that person has been lawfully admitted for permanent residence in the United States under the Immigration and Naturalization Act. The term also means any foreign corporation (i.e., a corporation that is not incorporated in a state, district or territory of the United States), business association, partnership, society, trust, or any other entity not incorporated or organized to do business in the United States, and any international organization, foreign government, and any agency or subdivision of a foreign government (e.g., a diplomatic mission). See 22 C.F.R. § 120.16.

Section 1.08 The term **"Government End-Users"** means ....

Section 1.09 The term **"ITAR"** means the International Traffic in Arms Regulations, codified at 22 C.F.R. Parts 120 130, promulgated and administered by DTC, pursuant to the authority granted pursuant to the Arms Export Control Act, 22 U.S.C. § 2778.

Section 1.10 The term **"Licensees"** means CANEUS International, Company A, B, C...

Section 1.11 The term **"Licensors"** means CANEUS USA and Company A…

Section 1.12 The term **"Scope Statement"** means the statement attached as "Annex A," which defines the scope of the Technical Data and Defense Services authorized by DDTC for export by the Licensors to the Licensees.

Section 1.13 The term **"Sub-licensee"** means an entity identified as such in Section 2.04(a) and Annex A.

Section 1.14 The term **"Technical Data"** means information that is directly related to the design, engineering, development, production, processing, manufacture, assembly, testing, use, operation, overhaul, repair, maintenance, modification, or reconstruction of a Defense Article or otherwise specifically identified on the USML. This includes, for example, information in the form of blueprints, drawings, photographs, plans, instructions, computer software and documentation. The term "Technical Data" does not include information concerning general scientific, mathematical or engineering principles, or basic marketing information on function or purpose or general systems descriptions of Defense Articles. See 22 C.F.R. § 120.10.

Section 1.15 The term **"Territory"** means Canada, the United States and ..

Section 1.16 The term **"Third Country National"** means an individual holding nationality from a country or countries other than the country of a foreign Licensee to this Agreement.

Article II

Technical Assistance and ITAR Section 124.7 Required Information

Section 2.01 Effective Date and Duration of Agreement (ITAR § 124.7(3)). This Agreement shall be effective as of the Effective Date, first written above, which date the Parties certify is a date on or after: (a) the approval of this Agreement by DDTC; and (b) the execution of this agreement by all Parties. This Agreement shall terminate upon the earliest of: (a) February 28, 2019; (b) 30-day written notice sent by the Applicant terminating this Agreement in whole or in part (i.e., with respect to one or more Parties, in which case the Agreement will only terminate as to such terminated Party or Parties); or (c) a direction of DDTC to terminate this Agreement. If this Agreement is terminated with respect to a particular Party, the rights and obligations of the remaining Parties shall remain unaffected.

Section 2.02 Limitations on Disclosure of Information and Technology. This Agreement does not (a) obligate any Party to transfer information or technology, including Technical Data and Defense Services, to another Party; or (b) authorize any Party receiving information or technology from another Party to transfer such information or technology to a third party, including a third party that is a Party to this Agreement. Disclosure of such information or technology is purely voluntary. However, in the event that a Party desires to disclose Technical Data and Defense Services such transfers must be pursuant to the terms of this Agreement. This Agreement has been approved by the DDTC and the Parties may not act beyond the terms set forth in this Agreement without an amendment to the agreement that has been approved by the DDTC.

Section 2.03 Export and Use of Technical Data and Defense Services (ITAR § 124.7(2, 4))

(a) Any and all Technical Data and Defense Services furnished by the Licensors to the Licensees in furtherance of this Agreement:

(i) are released for the limited purpose of, and use in connection with, an Approved Program;

(ii) may be used only in the Territory as defined above; and

(iii) may not be transferred except (1) among the Parties and Government End-Users, or (2) by a Licensee to a Sub-licensee as limited by Section 2.04.

(b) The Parties acknowledge that DDTC has authorized the export of only the Technical Data and Defense Services described in the Scope Statement in Annex A.

Section 2.04 Sub-licensing (ITAR § 124.7(4))

(a) A foreign Licensee may retransfer Technical Data and Defense Services to the following third parties ("Sub-licensees"), subject to the limitations on retransfer set forth in the Scope Statement:

NONE APPROVED AT THIS TIME

(b) Sub-licensing/retransfer by the foreign Licensee to non-U.S. persons is not authorized unless and until the Department of State provides prior written approval of the Sub-licensee pursuant to the limitations on sub-licensing set forth in the Scope Statement.

Section 2.05 Hardware (ITAR § 124.7(1)). The Parties do not anticipate that the Licensors will export or otherwise deliver any hardware Defense Articles to the Licensees in furtherance of this Agreement. This Agreement does not include the release of any manufacturing know-how, or the granting of any rights specifically for the production or manufacture of any Defense Articles.

Section 2.06 Limitations on Re-export or Re-transfer. Licensees shall hold the Technical Data and Defense Services released pursuant to Section 2.03 in trust and in the strictest confidence and shall not furnish, deliver, release, communicate, disclose or otherwise provide such Technical Data or Defense Services to third parties, except:

(a) to the Licensees' employees, provided they are not citizens or nationals of countries listed in Section 126.1 of the ITAR and are in compliance with Section 2.07; or
(b) to a Sub-licensee, but only after the Sub-licensee signs a Non-Disclosure Agreement in the form attached as Annex B and only to the extent provided in Section 2.04.

Section 2.07 Release to Employees.

(a) Pursuant to ITAR section 124.16, this Agreement authorizes access to unclassified defense articles and/or retransfer of technical data/defense services to individuals who are dual/third country national employees of the foreign Licensees. The exclusive nationalities authorized are limited to NATO, European Union, Australia, Japan, New Zealand, and Switzerland. All access and/or retransfers must take place completely within the physical territories of these countries or the United States.
(b) Pursuant to ITAR section 124.8(5), this Agreement authorizes access to defense articles and/or retransfer of technical data/defense services to individuals who are third country/dual national employees of the foreign licensee. The exclusive nationalities authorized are listed below:

[INSERT LIST OF NATIONALITIES OF THE EMPLOYEES OF THE LICENSEE OTHER THAN THOSE COVERED IN SECTION 2.05(a) ABOVE]

Prior to any access or retransfer, the employee must execute a Non-Disclosure Agreement ("NDA") referencing this DTC case number. The Applicant must maintain copies of the executed NDAs for five years from the expiration of this Agreement.

(c) Pursuant Transfers to employees of the Licensee who are Third Country Nationals or Dual Nationals of a country that is not listed in paragraphs (a) or (b) may take place only after: (i) DDTC approves an amendment to the Agreement which identifies countries of origin and nationality of the employee; and (ii) the Third Country National or Dual National has executed a NDA referencing this DTC case number as set forth in paragraph (d). The Applicant must maintain copies of the executed NDAs for five years from the expiration of this Agreement.

(d) Any NDA executed pursuant to paragraphs (b) or (c) above must include, at a minimum, the following certification in substance, and the executed agreement has been delivered to Licensor prior to such access:

> "DDTC CASE NO. [TBD]
>
> I, ___________________, acknowledge and understand that any technical data related to defense articles on the U.S. Munitions List, to which I have access or which is disclosed to me under the above-referenced case by [Licensee] is subject to export control under the International Traffic in Arms Regulations (Title 22, Code of Federal Regulations, parts 120-130). I hereby certify that such data will not be further disclosed, exported or transferred in any manner, to any other foreign national or any foreign country without the prior written approval of the Office of Trade Controls Licensing, U.S. Department of State."

(e) Pursuant Contract employees to any Party to the agreement hired through a staffing agency or other services contract shall be treated as employees of the Party, and that Party is legally responsible for the employees' actions with regard to transfer of ITAR controlled defense articles and defense services. The Party is further responsible for certifying that each employee is individually aware of their responsibility with regard to the proper handling of ITAR controlled defense articles and defense services.

Section 2.08 Releasable Licensed Technology. The limitations on the disclosure of Technical Data in this Article II shall not apply to:

(a) Basic marketing information or general system descriptions; or

(b) Technical Data which is, or becomes, published and generally accessible or available to the public: (i) through sales at newsstands and bookstores; (ii) through subscriptions which are available without restriction to any individual who desires to obtain or purchase the published information; (iii) through second class mail privileges granted by the U.S. Government; (iv) at libraries open to the public or from which the public can obtain documents; (v) through patents available to the public at any patent office; (vi) through unlimited distribution at a conference, meeting, seminar, trade show or exhibition in the United States; or (vii) through unlimited distribution, in any form, after approval by the cognizant U.S. Government department or agency.

Section 2.09 Compliance

(a) Licensees understand that the U.S. Government has the authority to restrict or prohibit: business dealings between Foreign Persons and Parties who are not Foreign Persons; exports of goods, technology and services to Licensees, and re-exports and other transfers of U.S. origin goods, technology and services by Licensees to third parties. Parties shall be excused from performance under this Agreement or under any other agreement, and shall not be liable or accountable to Licensees for any loss or damage whatsoever, including lost profits or other indirect or incidental damages, to the extent that an act or omission of the U.S. Government (including acts or omissions of Congress and the Judiciary) or any law, regulation, directive, order or approval that restricts, prohibits or delays performance of an obligation.

(b) Licensees understand that the Technical Data and Defense Services that they may receive in connection with this Agreement are controlled by the U.S. Government and cannot be sold, leased, sublicensed, or otherwise transferred, except pursuant to United States Government authorization. Licensees shall implement and follow all procedures and instructions from the Applicant to comply with applicable laws, regulations and administrative actions of the United States Government and shall not engage in any activity that could subject the Applicant or other U.S. persons to civil, criminal or administrative liability.

(c) The Parties agree to comply with all applicable sections of the ITAR. Further, Licensees shall not make, offer, promise or authorize any payment, loan, gift, donation or other giving of money or things of value, directly or indirectly, whether through Licensees, their affiliates, partners, officers, employees, agents or representatives, whether in cash or kind, and whether pursuant to a written contract, to or for the use of any government official, any political party or official thereof, or any candidate for political office, for the purpose of influencing or inducing any official act or decision in order to further the activities contemplated by this Agreement, including obtaining or retaining any license or funding related to such activities.

(d) No shipment of hardware, software, Defense Articles, Technical Data or Defense Services may take place against this Agreement unless and until an executed copy of this Agreement, once approved by DDTC, is deposited with DDTC. The Applicant shall deposit with DDTC an executed copy of this Agreement within thirty (30) days of the date of the last signature.

(e) Pursuant to ITAR § 123.22(b)(3)(ii), the Applicant shall notify the DDTC prior to the initial export of Technical Data and/or Defense Services under this Agreement. Until the implementation of the DS-4071 electronic reporting system, the Applicant shall notify the DDTC via paper submission (i.e., letter) with the following attention line: "ATTN: Initial Export Notification for Agreement DDTC Case No. [TBD]." Records of all subsequent exports of Technical Data in furtherance of this Agreement shall be maintained by the Licensors and shall be made immediately available to the DDTC upon request.

(f) Licensees shall not assign this Agreement or any of its rights or obligations under this Agreement without the prior written consent of Applicant and the approval of the DDTC. Any attempted, unpermitted assignment shall be void from the date of attempted assignment.

Article III

ITAR Provisions

Section 3.01 ITAR § 124.8(1) This Agreement shall not enter into force, and shall not be amended or extended, without the prior written approval of the United States Department of State.

Section 3.02 ITAR § 124.8(2) This Agreement is subject to all United States laws and regulations relating to exports and to all administrative acts of the U.S. Government pursuant to such laws and regulations.

Section 3.03 ITAR § 124.8(3) The Parties to this Agreement agree that the obligations contained in this Agreement shall not affect the performance of any obligations created by prior contracts or subcontracts which the parties may have individually or collectively with the U.S. Government.

Section 3.04 ITAR § 124.8(4) No liability will be incurred by or attributed to the U.S. Government in connection with any possible infringement of privately owned patent or proprietary rights, either domestic or foreign, by reason of the U.S. Government's approval of this Agreement.

Section 3.05 ITAR § 124.8(5) The Technical Data and Defense Services exported from the United States in furtherance of this Agreement, and any Defense Article which may be produced or manufactured from such Technical Data or Defense Service, may not be transferred to a person in a third country or to a national of a third country except as specifically authorized in this Agreement unless the prior written approval of the Department of State has been obtained.

Section 3.06 ITAR § 124.8(6) All provisions in this Agreement which refer to the United States Government and the Department of State will remain binding on the parties after the termination of the Agreement.

Article IV

General

Section 4.01 Governing Law. This Agreement shall be governed by, and construed in accordance with, the applicable United States federal laws and regulations and the laws of the State of Delaware, USA. This Agreement is subject to, and the Parties agree to comply with, the ITAR and other export control laws and regulations of the United States governing imports and exports.

Section 4.02 Representations and Warranties. Each Party represents and warrants that this Agreement has been duly authorized, executed and delivered by the respective Party and constitutes the valid and binding obligation of such Party and is enforceable against such Party in accordance with its terms.

Section 4.03 Limitation of Liability. Notwithstanding any provision of this Agreement to the contrary, no Party will be entitled, in connection with any breach or violation of this Agreement, to exemplary or other special damages or any indirect, incidental or consequential damages, including without limitation damages relating to loss of profit, business opportunity or business reputation. Notwithstanding the preceding sentence, a Party shall be entitled to pursue damages related to loss of profit, business opportunity or business reputation, if the breach or violation is knowing and intentional or fraudulent. Excluding breaches or violations that are knowing and intentional or fraudulent, each Party, as a material inducement to the other Parties to enter into and perform their obligations under this Agreement, hereby expressly waives its rights to assert any claim relating to such damages and agrees not to seek to recover such damages in connection with any claim, action, suit or proceeding relating to this Agreement, other than as provided in the preceding sentence of this section.

Section 4.04 Entire Agreement; Interpretation and Construction. This Agreement, and the exhibits attached to this Agreement, which shall be deemed to be part of this Agreement and subject to its terms, constitute the entire agreement among the Parties concerning the subject matter of this Agreement and supersede all prior agreements and understandings, whether written or oral, regarding the subject matter of this Agreement. Where the context so requires, the singular shall include the plural. The headings and captions of this Agreement are inserted for convenience and identification only and are in no way intended to define, limit or expand the scope and intent of this Agreement or any provision hereof.

Section 4.05 Waiver of Provisions. No failure to exercise, and no delay in exercising, on the part of a Party of any right, power or privilege under this Agreement shall preclude any other or further exercise of such right, power or privilege or the exercise of any other right, power or privilege.

Section 4.06 Binding on Successors. The terms, conditions and provisions of this Agreement shall inure to the benefit of, and be binding upon, the Parties and their respective heirs, successors, transferees and assignees.

Section 4.07 Severability. Each provision of this Agreement shall be considered severable, and if for any reason any provision or provisions of this Agreement are determined by a competent authority to be invalid or contrary to any existing or future law of any jurisdiction or any rule or regulation of any governmental authority, such provision shall be construed or limited in such a way as to make it enforceable, consistent with the manifest intentions of the Parties.

Section 4.08 Amendment. Except as otherwise provided in Section 4.09, this Agreement may only be amended or modified by written consent of all applicable Parties. Any amendment or modification shall become effective in accordance with its terms after such amendment or modification is appropriately approved by the Department of State and such modification or amendment is executed by each of the Parties.

Section 4.09 Amendment to Charter Membership. Notwithstanding Section 4.08, the Parties agree that the Applicant may, without the written consent of any other Party, add or remove Licensors, Licensees, or Sub-licensees to the Agreement by amend or modify: (a) the definitions Licensors, Licensees, or Sub-licensees to this Agreement; (b) the definition of the Territory to reflect the nationality of the Parties to this Agreement; and (c) the permitted list of nationalities authorized for dual/third country national employees set forth in Section 2.07(b) to this Agreement. Any amendment or modification under this Section shall become effective in accordance with its terms after such amendment or modification is appropriately approved by the Department of State and such modification or amendment is executed by the Applicant and the added or removed Licensor or Licensee and a copy of the amendment is sent to all Parties.

Section 4.10 Counterparts. This Agreement may be executed in counterparts, each of which shall be deemed an original, and all counterparts taken together shall constitute the agreement of the Parties.

Section 4.11 Rule of Construction. The Parties to this Agreement acknowledge that they have each carefully read and reviewed this Agreement and, therefore, agree that the rule of construction that ambiguities shall be construed against the drafter of the document shall not be applicable.

Section 4.12 Controlling Language. English is the controlling language of this Agreement.

IN WITNESS WHEREOF, each of the Parties has caused this Agreement to be executed by its duly authorized representative.

CANEUS USA Inc.

By: ______________________________
[NAME, TITLE]

Date: _______________

CANEUS International

By: ______________________________
[NAME, TITLE]

Date: _______________

Company A

By: ______________________________
[NAME, TITLE]

Date: _______________

Company B

By: ______________________________
[NAME, TITLE]

Date: _______________

Organization C

By: ______________________________
[NAME, TITLE]

Date: _______________

The following Government End-Users acknowledge their desire that the Consortium develop the Fly-By-Wireless solutions contemplated by this Agreement:

Agency A

By: ______________________________
[NAME, TITLE]

Date: _______________

Agency B

By: ______________________________
[NAME, TITLE]

Date: _______________

Agency C

By: ______________________________
[NAME, TITLE]

Date: _______________

Agency D

By: ______________________________
[NAME, TITLE]

Date: _______________

Annex A

Scope Of Technical Data And Defense Services

I. OVERVIEW OF SCOPE AND PARTIES

A. Scope Overview

The Parties and Government End-Users are the charter members of the CANEUS Fly-by-Wireless Sector Consortium (the "Consortium"). The purpose of the Consortium is to minimize cables and connectors and increase functionality in aerospace applications, including for spacecraft, through micro- and nano-technology ("MNT") items to provide reliable, lower cost, modular, and higher performance alternatives to wired data connectivity to benefit the entire vehicle/program life-cycle

The purpose of this TAA is to allow the Parties to collaborate on the development of standards, definitions and specifications for Fly-By-Wireless solutions to be used in spacecraft applications by or for the following U.S., Canadian and European Government end-users: A, B, C,...(collectively, the "Government End-Users"). The MNT technology and possible Fly-By-Wireless solutions are at an early stage of technology readiness. A variety of potential applications are expected to surface beyond use in the space program. For example, the Parties intend that the standards, definitions and specifications for Fly-By-Wireless solutions will be used or adapted for use in civilian aerospace applications. [PLEASE NOTE THAT WE HAVE PURPOSEFULLY EXCLUDED MILITARY END-USES FROM THIS DESCRIPTION]

The activities contemplated under this TAA are broadly as follows:

(a) formulation of end-user and customer needs as related to (i) aircraft and spacecraft structural health and monitoring, (ii) passive wireless tag, (iii) "less-wire" architectures, (iv) sensor DAQ micro-miniaturization, and (v) wireless systems immunity in electromagnetic environments;

(b) the development of project concepts from end-users that that could offer potential solutions for identified needs;

(c) the identification of current technology and project developments by Fly-By-Wireless technology providers from Canada, the United States, Europe, Brazil, and Japan;

(d) the identification of the maturity level of current developments in Fly-By-Wireless technology; and

(e) documenting the research in standards, definitions and specifications.

In most instances, these activities only involve conceptual elements that do not arise to the level of Technical Data or Defense Services. However, as the development of these concepts mature, it becomes less clear whether the transfer of information arises to a transfer of Technical Data or Defense Services. This TAA is required to encourage collaboration in the development of Fly-By-Wireless applications. Such transfers will provide Agency A, B, and potentially other U.S. Canadian and European Government programs access to innovative non-U.S. technologies, capabilities, and products that will ultimately reduce costs associated with materials, design architecture, maintenance, and safety for aerospace and space applications. Moreover, the synergies created by combining U.S. and non-U.S. technologies will promote rapid development in this field to the benefit of the Governments.

B. Territory

The Territory for collaboration is Canada, the United States and Europe.

C. Participating Entities Facilities / Addresses

1. Applicant and U.S. Licensee
   CANEUS USA Inc.
   140 Queens Lane
   Canfield, OH USA 44406

2. Other U.S. Licensors
   Company A

3. Foreign Licensees
   CANEUS International
   431 Brock Avenue
   Montreal, Quebec
   Canada H4X 2G6;
   Company B
   Company C

4. Government End-Users
   Agency A
   Agency B
   Agency C

5. Foreign Sub-licensees
   None.

D. Roles and Responsibilities

[TO BE RESTATED FROM THE PREAMBLE WITH PLACE HOLDER FOR FUTURE SUBLICENEES]

II. TECHNICAL DATA

Technical data that may be exported by the U.S. Licensors pursuant to this TAA are:

- Documents, drawings, technical reports, and such information related to connectivity and structural health monitoring for the end-user's aerospace and space applications.
- The end-user's requirements and specifications as they relate to connectivity, structural health monitoring for aerospace and space applications including
  0 conditions that alter the propagation channel
  0 susceptibility to electromagnetic interference and jamming signals
  0 synchronization issues
  0 wireless security
  0 power limitations
  0 troubleshooting
- Concept of operations of the end-user's systems or equipment.
- Internal consistency of operations documentation relating to
  0 Common design characteristics, standards and definitions
  0 Standardization of definitions
  0 Standardization of quality, inspection, and test procedures

The requirements and specifications generally may include environmental and structural conditions and interface requirements related to the program or application in which Fly-by-Wireless technology may be employed. Environmental and interface data may include, for example, requirements for:

- Quantity of sensors needed for monitoring
- Temperature
- Pressure
- Acceleration

- Strain
- Acoustic emission
- Electromagnetic interference levels
- Frequency and phase stability, including phase noise performance
- Vibration and shock levels
- Moisture range
- Vacuum level
- Input and output parameters
- Power supply levels
- Altitude
- Flammability
- Corrosion
- Physical characteristics
- Mechanical configuration
- Weight
- Electrical connections
- Pin assignments
- Frequency stability
- Warm-up time
- Safety measures and handling [ARE THESE RELEVANT?]

Technical data that may not be exported by U.S. Parties pursuant to this TAA include:

- Design methodology, such as: the underlying engineering methods and design philosophy utilized (i.e., the "why" or information that explains the rationale for particular design decision, engineering feature, or performance requirement); engineering experience (e.g., lessons learned); and the rationale and associated databases (e.g., design allowables, factors of safety, component life predictions, failure analysis criteria) that establish the operational requirements (e.g., performance, mechanical, electrical, electronic, reliability and maintainability) of a defense article.
- Engineering analysis, such as: analytical methods and tools used to design or evaluate a defense

article's performance against the operational requirements. Analytical methods and tools include the development and/or use of mockups, computer models and simulations, and test facilities.

- Manufacturing know-how, such as: information that provides detailed manufacturing processes and techniques needed to translate a detailed design into a qualified, finished defense article.
- Classified data/information.
- U.S. Government information except as directly related and necessary in developing Fly-by-Wireless technology for the end-user.
- The U.S. Licensors will not augment or suggest changes that optimize, enhance, improve, or increase the foreign Licensees' processes and/or their capability for design, development, or manufacture. This limitation does not affect the U.S. Licensors' ability to discuss requirements, specifications, interfaces, functions, and performance.

III. DEFENSE SERVICES

The U.S. Parties will furnish defense services to the foreign Licensees in relation to the following activities:

- formulation of end-user and customer needs as related to (i) aircraft and spacecraft structural health and monitoring, (ii) passive wireless tag, (iii) "less-wire" architectures, (iv) sensor DAQ micro-miniaturization, and (v) wireless systems immunity in electromagnetic environments;
- the development of project concepts from end-users that that could offer potential solutions for identified needs;
- the identification of current technology and project developments by Fly-By-Wireless technology providers from Canada, the United States, Europe, Brazil, and Japan;
- the identification of the maturity level of current developments in Fly-By-Wireless technology;
- documenting the research in standards, definitions and specifications;
- Promoting the advancement and development of Fly-by-Wireless technology for use in aerospace applications;
- Evaluating end-users' requirements or needs;
- Reviewing RFPs for end-user programs and evaluating how and if program requirements may be met;
- Evaluating the application or modification of Fly-by-Wireless applications to meet such requirements or needs;
- Preparation and presentation of proposals to other Parties; and
- Responding to questions and requests for additional information regarding presentations and proposals to other Parties.

Annex B

Sample NDA For Sublicensing

NON-DISCLOSURE AGREEMENT
For DTCL Case(s) ___________

I, ____(name)____, an authorized representative of ____(Sub-Licensee)____, acknowledge and understand that any technical data related to defense articles on the U.S. Munitions List, to which is disclosed under this license(s) by (Foreign Licensee) is subject to export control under the International Traffic in Arms Regulations (Title 22 Code of Federal Regulations, parts 120-130) specifically Sections 124.8 and 124.9:

§124.8(1). This agreement shall not enter into force, and shall not be amended or extended, without the prior written approval of the Department of State of the U.S. Government.

§124.8(2). This agreement is subject to all United States laws and regulations relating to exports and to all administrative acts of the U.S. Government pursuant to such laws and regulations.

§124.8(3). The parties to this agreement agree that the obligations contained in this agreement shall not affect the performance of any obligations created by prior contracts or subcontracts which the parties may have individually or collectively with the U.S. Government.

§124.8(4). No liability will be incurred by or attributed to the U.S. Government in connection with any possible infringement of privately owned patent or proprietary rights, either domestic or foreign, by reason of the U.S. Government's approval of this agreement.

§124.8(5). The technical data or defense service exported from the United States in furtherance of this agreement and any defense article which may be produced or manufactured from such technical data or defense service may not be transferred to a person in a third country or to a national of a third country except as specifically authorized in this agreement unless the prior written approval of the Department of State has been obtained.

§124.8(6). All provisions in this agreement that refer to the U.S. Government and the Department of State will remain binding on the parties after the termination of the agreement.

I hereby certify that such data will not be further disclosed, exported or transferred in any manner, to other foreign national or any foreign country without the prior written approval of the Directorate of Trade Controls, U.S. Department of State.

______________________________	______________________________
Signature Block of Sub-Licensee (Customer)	Signature Block of Foreign Licensee
_________________	_________________
Date	Date

WASHINGTON/264908.1

Appendix F. *Glossary*

A

ARP (Air Research Project)

C

CCC (Canada Commercial Corporation)
CRIAQ (Consortium for Research and Innovation in Aerospace in Quebec)
CSE (Communications Security Establishment)

D

DAQ (Data Acquisition)
DPHM (Diagnostics Prognostics & Health Management)

E

EC (European Commission)
EDC (Export Development Canada)
EMI (Electro-magnetic interference)
EMC (Electro-magnetic compatibility)
EMAT (Electro-magnetic Acoustic Transducer)
EMP (Elec tromagnetic Pulse)

F

FCC (Federal Communication Commission)
FBW (Fly-By-Wireless)

H

HIRF (High intensity radio frequency)

I

IP (Intellectual Property)
ITAR (International Traffic and Arms Regulation)
IVHM (Integrated Vehicle Health Management)

L

LTA (Lightning Transient Analysis)

M

MEMS (Micro-Electro-Mechanical Systems)
MNT (Micro-Nano-Technology)

N

NDE (Non Destructive Examination)
NDA (Non-Disclosure Agreement)
NSERC (National Sciences and Engineering Research Council)

P

PSD (Power Spectrum Density)

R

RFID (Radio-Frequency Identification)
ROI (Return on Investment)

S

SAW (Surface Acoustic Wave)
SBIR (Small Business Innovation Research)
SHM (Structural Health Monitoring)
STTR (Small Business Technology Transfer)

T

TAA (Technical Assistance Agreement)
TRL (Technology Readiness Level)

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